2

X.2 LIMITED FLIGHT TEST PLAN

Prepared for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

15 March 1989

Contract #MDA972-88-C-0058 A06390

AeroLift Inc.
4105 Blimp Blvd.
Tillamook, Oregon 97141
503-842-8891

LIMITED FLIGHT TEST PLAN

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CON'T)

LIMITED FLIGHT TEST PLAN

ABBREVIATION TERMINOLOGY

ABBREVIATION	TERM
AACOM	Division of Datum, Inc.
APU	Auxilliary Power Unit
ASTO	Aerospace Technology Office
DARPA	Defense Advanced Research Projects Agency
db	Decibel
DC	Direct Current
DOD	Department of Defense
FRR	Flight Readiness Review
GFE	Government Furnished Equipment
GOD	Ground Operations Director
GSE	Ground Support Equipment
MRS	Mississippi Road Service
MHZ	Megahertz
PCM-FM	Pulse Code Modulation Frequency Modulation
RF	Radio Frequency
X.2	Experimental 2-ton CycloCrane

1. INTRODUCTION

X.2 LIMITED FLIGHT TEST PLAN

1.0 INTRODUCTION

The X.2 Limited Flight Test Plan is the second deliverable product under the Defense Advanced Research Projects Agency/Aerospace Technology Office (DARPA/ASTO)'s CycloCrane Program. (Item number 0002AB, Contract number MDA972-88-C-0058). The guidelines for this plan were presented in the "Detailed Program Plan for Further Development and Limited Flight Testing of the CycloCrane", dated October 14, 1988.

The principal objectives of the planned tests are to (1) assess a number of ground handling scenarios for the X.2 system to determine the preferred mix of Ground Support Equipment (GSE) and personnel for efficient and safe field operations, and (2) obtain specific performance data needed to support design development; e.g., hover power of new, four engine configuration.

The following sections present particulars related to the planned test activities.

2. GROUND RULES

3. SYSTEM

TEST SCHEDULE

2.0 GROUND RULES

There are a number of ground rules which have been formulated by AeroLift, in conjunction with DARPA/Aerospace, to impose constraints on planned test work. These generally relate to issues of safety or specific requirements imposed by DARPA/Aerospace on conduct of the test program.

Established ground rules are listed as follows:

1. System tests shall be geographically constrained to the airfield boundary at the Port of Tillamook Bay, Tillamook, Oregon.

2. Single-line tether tests of the X.2 shall not (a) exceed line lengths of 2,000 feet, (b) have safety factors less than two, and (c) be initiated when winds in excess of 30 mph are expected at operating altitudes.

3. Multiple-line tether tests will have the same constraints as single-line tests (as indicated above).

4. Planned remote limited flight testing of the X.2 shall be restricted to less than 2,000 feet altitude with expected winds less than 30 mph.

5. All system tests involving powered vehicle operations will be in a "heavy" configuration; i.e., slingload or water ballast.

6. System tests shall not be initiated when wind conditions exceed 15 mph (crosswind component) on the X.2 when exiting the hangar.

7. System tests shall not be initiated if the required instrumentation/data subsystems are not operational.

8. Preparation for all planned tests shall be preceded by a full checkout of all hardware/equipment, rehearsal(s) of all required personnel for the required tests, and the employment of Checklists and Test Cards to assure proper execution of tasks.

9. Although a certain percentage of hydrogen is present in the aerostat during the helium purification process, at no time shall the maximum percentage be allowed to exceed 10%.

10. An updated Weight and Balance Sheet shall be available prior to each test to reflect any changes to initial sheet generated during FRR.

11. AeroLift shall notify DARPA/Aerospace 48 hours in advance of any planned system test; e.g., provide the government the opportunity to witness tests, if desired.

12. After each system test; e.g., Test T2 - X.2 Ground Handling, AeroLift shall review results with DARPA/Aerospace to determine effects, if any, on the next system test.

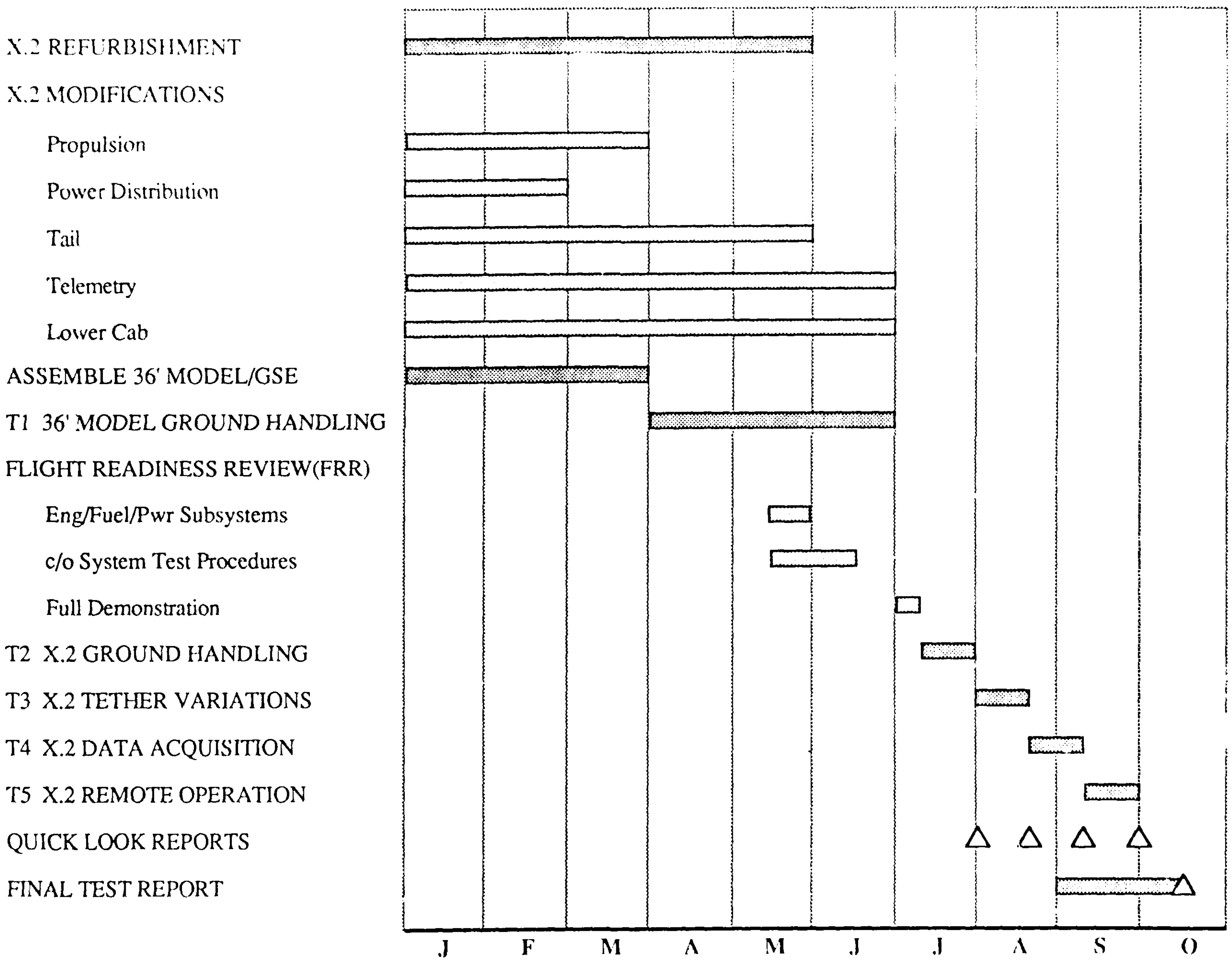
13. AeroLift shall provide for video recording of each system test.

3.0 SYSTEM TEST SCHEDULE

A preliminary schedule for testing was shown in the October "Program Plan" which indicated that the Flight Readiness Review (FRR) would occur in late March 1989, and the system (operational) tests would cover a five month period (April through August 1989). Since that time there have been some delays in the X.2 refurbishment/modification areas. In addition, during the development of this Plan, AeroLift desired a conservative schedule which recognized some contingency time for local weather problems and was keyed to hardware completion dates that appear achievable.

As a consequence, **Figure 1**, following this page, is the expected schedule for the system test efforts. Since the period for overall system testing is now three, rather than the initial five month projection, AeroLift has provided two modifications to facilitate a much more efficient system test phase. The two changes are (1) splitting the FRR into three segments to allow for DARPA/Aerospace reviews as hardware and procedures are ready, and (2) utilizing the existing 36 foot model of the X.2 as a major tool for training personnel and evaluating ground handling scenarios. That model related activity can (as shown) parallel other program tasks; e.g., perform activities for one or two hours at the start or at the end of each work day.

Figure 1. SYSTEM TEST SCHEDULE.



4. DESCRIPTION OF TEST ARTICLES

4.0 DESCRIPTION OF TEST ARTICLES

Fundamentally, a key issue for a CycloCrane system concept is how well it can be handled outside of a hangar in the field; while in a non-flying status. Evaluation of how well that can be done is the principal thrust of this test program. The recently completed tether tests with a 36 foot CycloCrane model showed that there is significant potential for elimination of the mobile mast and stalk dollies (which have been used for the X.2 CycloCrane in the past to go in and out of the hangar, as well as the basic GSE for field operations). The model tether tests also indicated that the degree of static lift attained (maximum) was a direct contributor to the success achieved on the single-line configuration of those tests.

As a consequence of the need for maximizing static lift, AeroLift made the decision to replace the two engine configuration of the experimental X.2 to the current four engine configuration which provides more total power with lower overall aircraft weight (improving static lift of the aircraft). It is noted that this approach was much more cost-effective (dollars and schedule time) than the obvious alternative -- a new, larger aerostat.

The new engines also resulted in changes to the telemetry and power distribution subsystems. Beyond these changes, the discussed model tether tests demonstrated that the ringtail configuration needed internal cross-members for final achievement of stability on the single tether. That model, as discussed in Section 3.0, will also be used in the preparatory phases of this test program.

As a consequence of all the above, a new description is necessary for the aircraft, along with the inclusion of the 36 foot model and its planned GSE. The test articles for the subject program are the Upgraded X.2 CycloCrane System and the 36 foot Model System.

- **UPGRADED X.2 CYCLOCRANE**

  The following discussion presents an overall description of the upgraded aircraft, plus the current and planned GSE. **Figure 2**, following this page, shows the previous X.2 experimental flight test at Tillamook.

Figure 2.
PREVIOUS X.2 EXPERIMENTAL FLIGHT TEST AT TILLAMOOK.

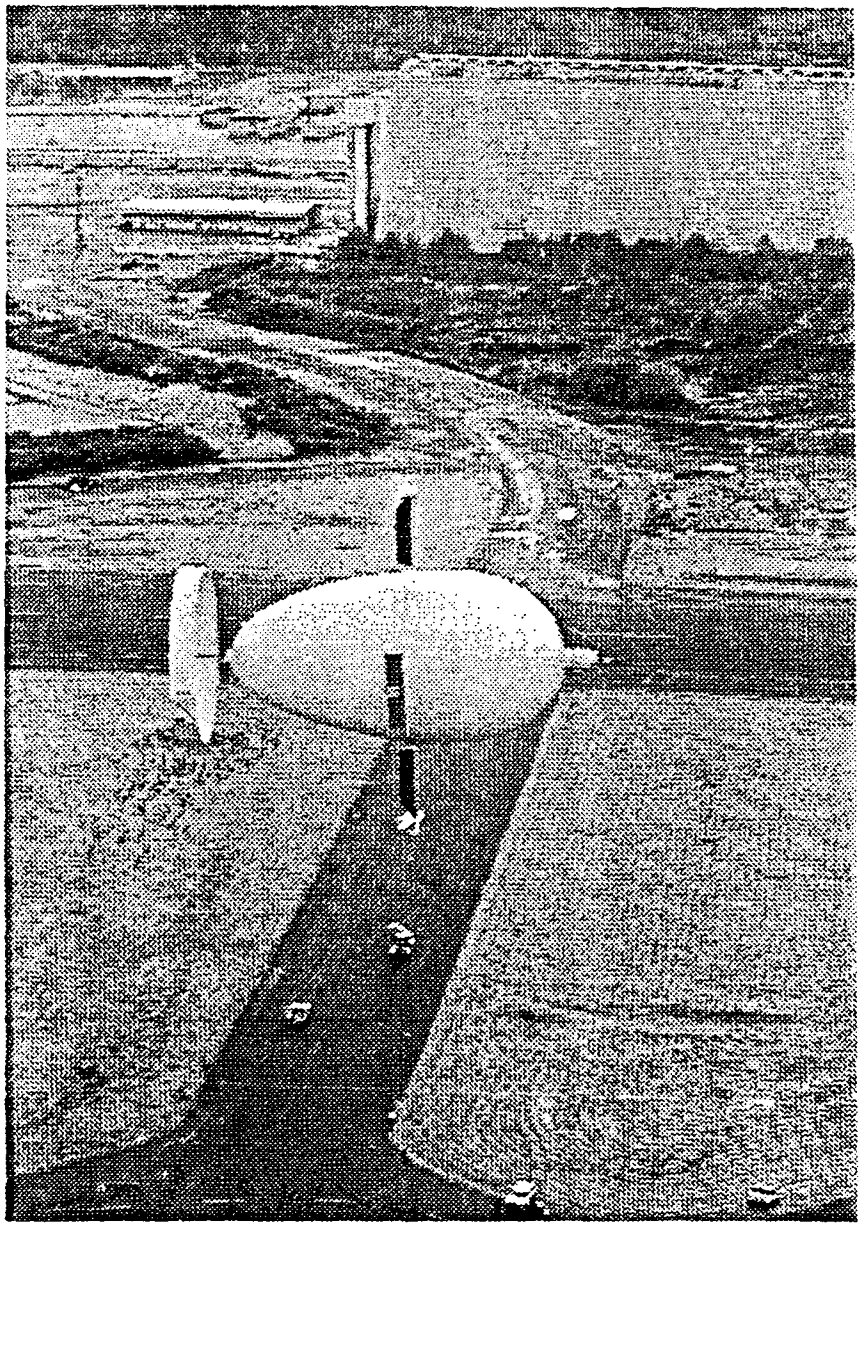


Figure 3, following this page, presents a perspective of the upgraded X.2 CycloCrane and **Figure 4** presents a three-view schematic. The aircraft is designed to carry a nominal payload of 2-tons. Its overall length is 178 feet and overall diameter (stalk tip-to-tip) is 140 feet. The aerostat and projecting "T"-form aerodynamic surfaces rotate in hover at 12.75 rpm maximum to provide a resultant airspeed of 60 mph over the wing surfaces (at the top of the "T"). One automatic control loop operates the thrust of the engine/propeller unit to provide the rotational torque corresponding to the particular airspeed/rpm circumstance. Another control loop senses the wing resultant direction and automatically orients the leading edge of the wing normal to the relative wind.

Currently, the cab and the payload are slung from bearing outer races at front and rear of the aerostat (recent studies indicate that certain mission requirements may dictate other locations which can be accommodated by the basic X.2 design). The tail, which is strictly for stability rather than control, is also mounted freely. The internal structure is arranged in space using Kevlar cables to tie together the longitudinal spine and the ends of the tubular cruciform structure which support the blades (base of the "T") and wings.

The blade-wing-engine assemblies ("stalks") are fixed outboard by external cables, while still allowing the blade and wing panel angles to be changed at the pilots will. The pilot and copilot have a set of helicopter type controls, which allow them to pitch and yaw the aircraft, and to translate along each of the three axis ("direct force control"). Collective variation in angularity of the blades provides positive and negative thrust; cyclic variation of blade angle creates pitching and/or yawing response. Cyclic variation in wing angle provides side force and/or positive or negative lift to supplement aerostatic lift.

Aerostatic buoyancy is designed to counteract approximately the vehicle's gross weight plus one-half of the payload weight, positively or negatively as the loading condition requires. The aerodynamic surfaces, which are sized to provide the controllability of an equivalent (payload) helicopter, are driven by hydraulic actuators through servo valves. Control commands are transmitted telemetrically by RF (backed up by an optical fiber link) from the cockpit to the aircraft's nose;

Figure 3. PERSPECTIVE OF UPGRADED X.2 CYCLOCRANE.

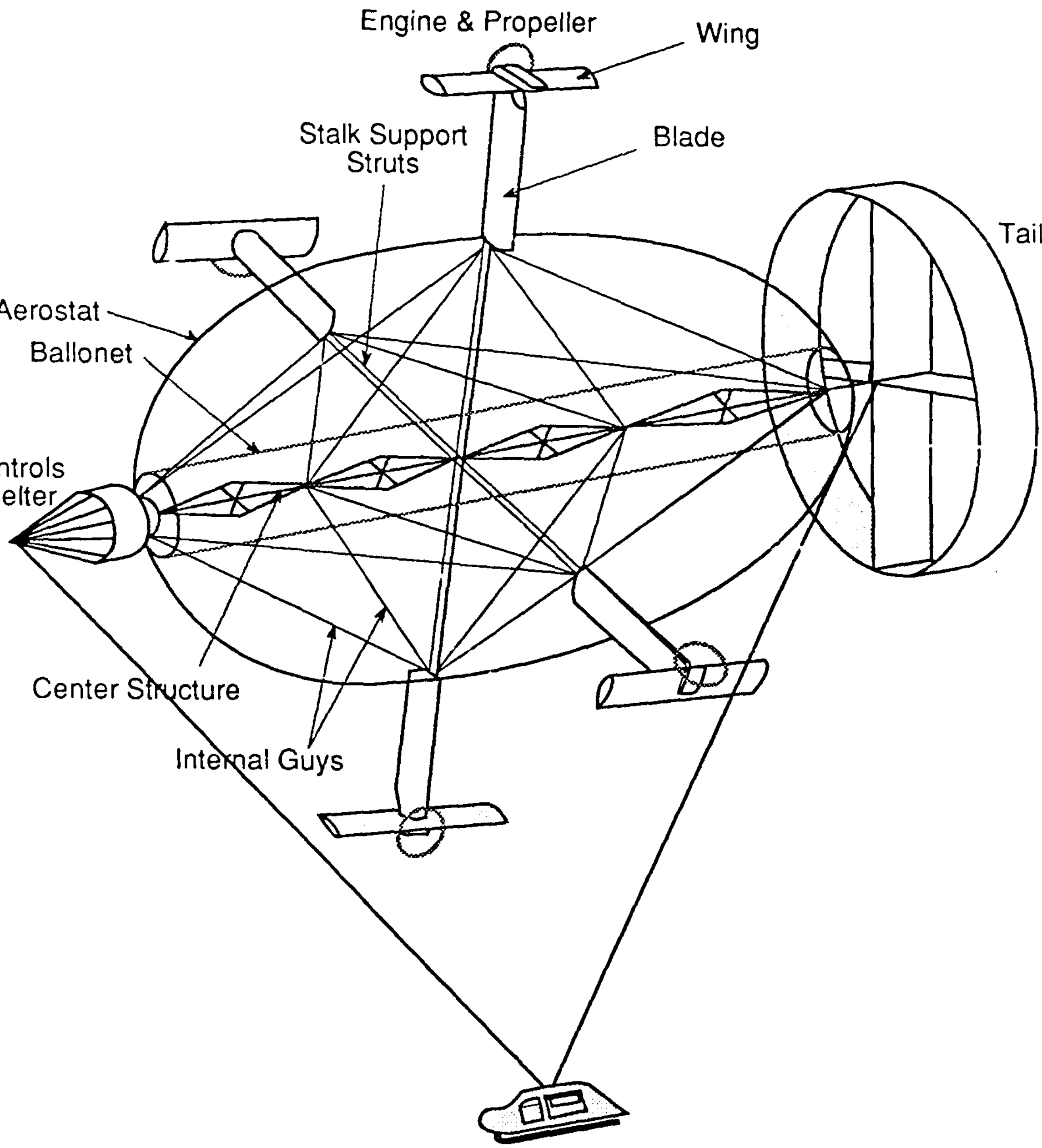
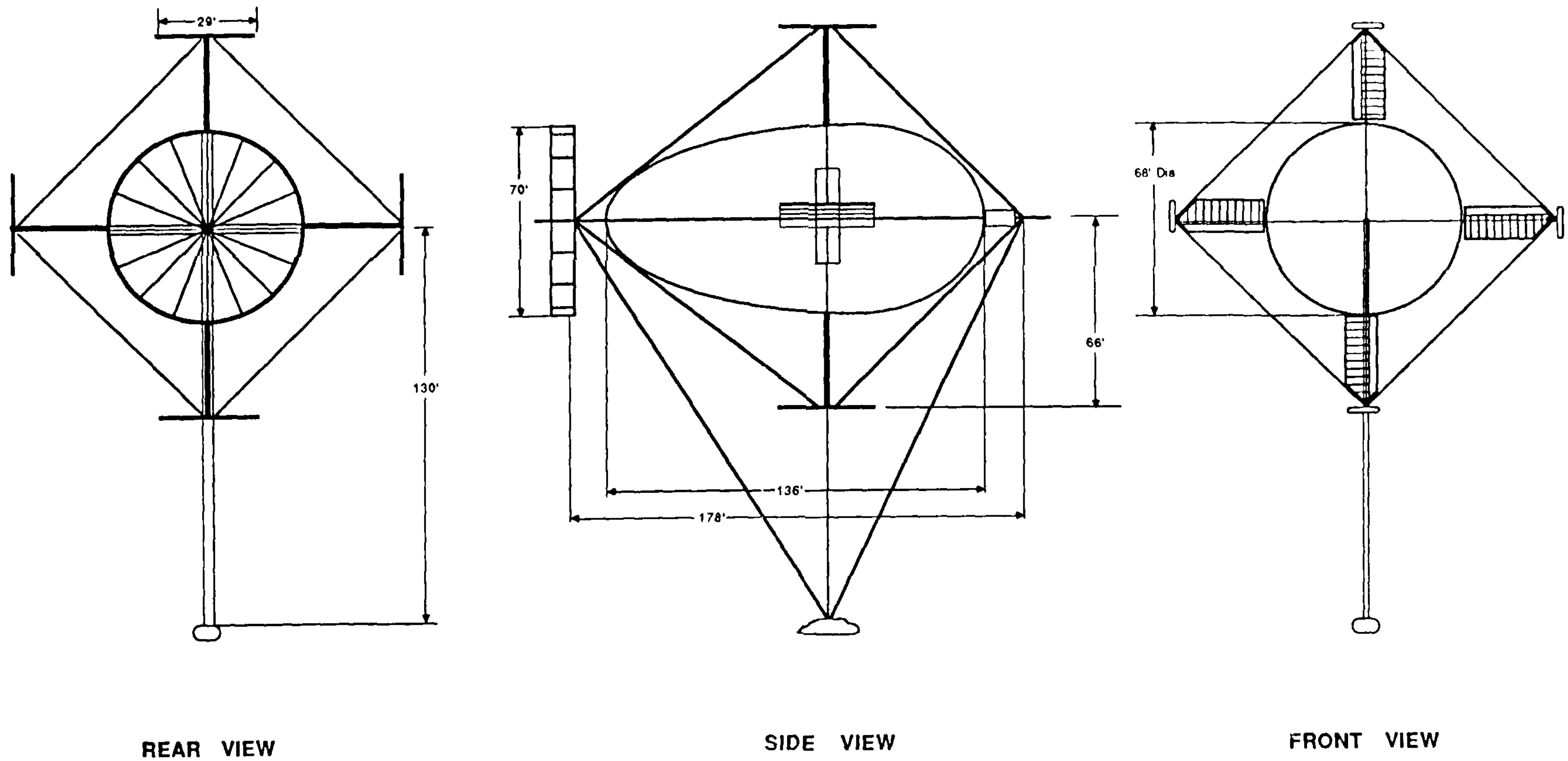


Figure 4. THREE-VIEW SCHEMATIC OF THE UPGRADED X.2 CYCLOCRANE



sliprings carry the signals into the rotating system, within which wires distribute the commands to the valves of the individual surfaces. **Figure** 5, following this page, shows a photograph of the stalks (depicting the "T" configuration of wings and blades.

Aerostat

The aerostat was designed and manufactured by ILC Dover. It has a diameter of 68 feet and is 136 feet long (see **Figure 6**). The fabric is a polyurethane coated dacron. There are four fabric tunnels within the aerostat to provide access to the structural members (see **Figure 7**). There is also an air-filled ballonet which runs the length of the aerostat with winches and fans which control, automatically, the hull internal pressures during altitude excursions and/or changes in temperature and barometric pressure as they occur. The ballonet as well as the four fabric tunnels allow access to the internal structure (see **Figure 8**).

Propulsion Subsystem

The X.2 CycloCrane is powered by four Hirth F-30 (110 horsepower each) two-stroke engines (see **Figure 9**). The total weight of these four engines with reduction belt drives and exhaust manifolds is 440 pounds. This reduction in total engine weight results in an increase in net buoyancy for the aircraft of 172 pounds. The four propellers are wooden, three-bladed fixed pitch with a diameter of 92 inches. The gear reduction system is 3.5:1, reducing the engine rpm from approximately 5,700 to a propeller rpm of approximately 1,800.

Telemetry Control Subsystem

The telemetry subsystem has been upgraded to accommodate the installation of four engines in place of the original two. It has a truly remote control operation and is relatively simple but reliable. It is a full duplex, PCM-FM data link capable of transmitting 96 discrete and 64 analog signals in each direction. Each channel is sampled at a rate of 64 times a second (this is considered an excellent sampling rate for wing movement between quadrants). Analog channels are digitized to 12 bits. A 12 bit system delivers accuracy of one part in 4096.

A unique system feature is that of data validation

Figure 5.
STALKS (NOTE "T" CONFIGURATION).

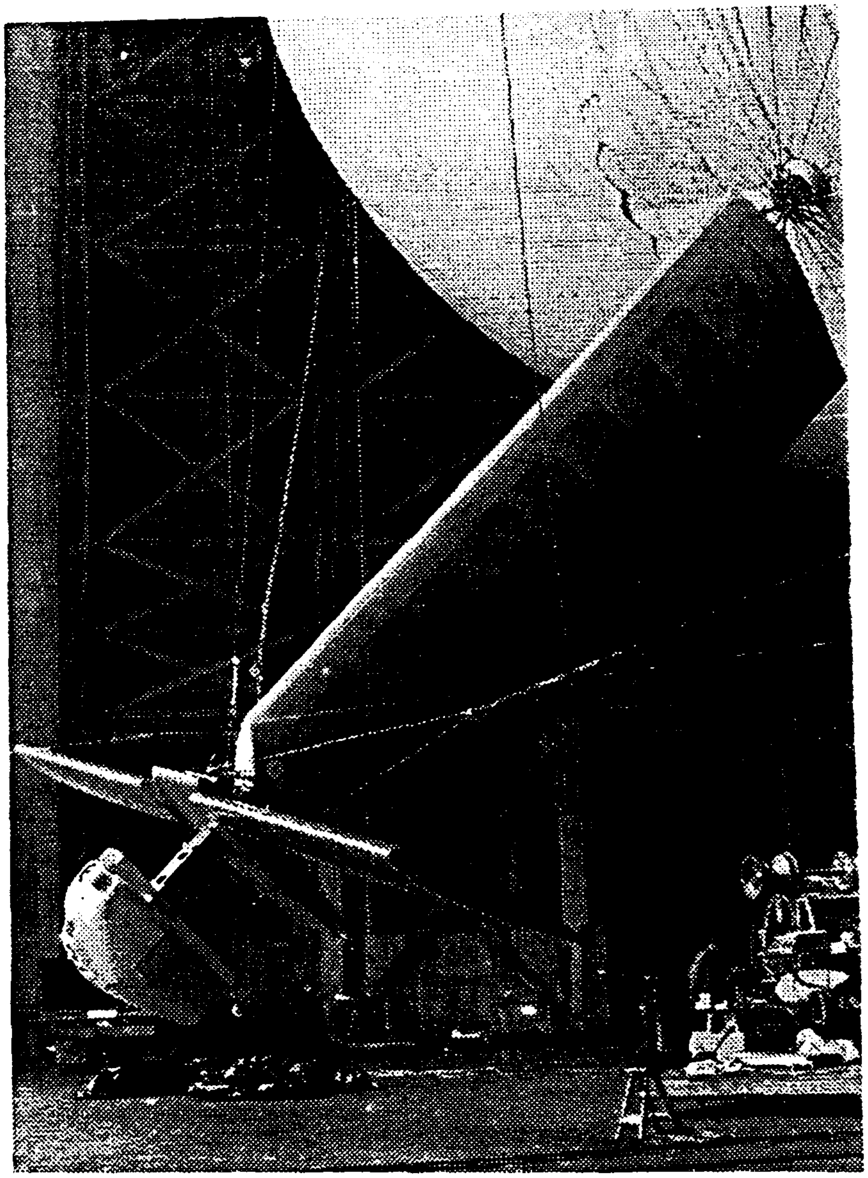
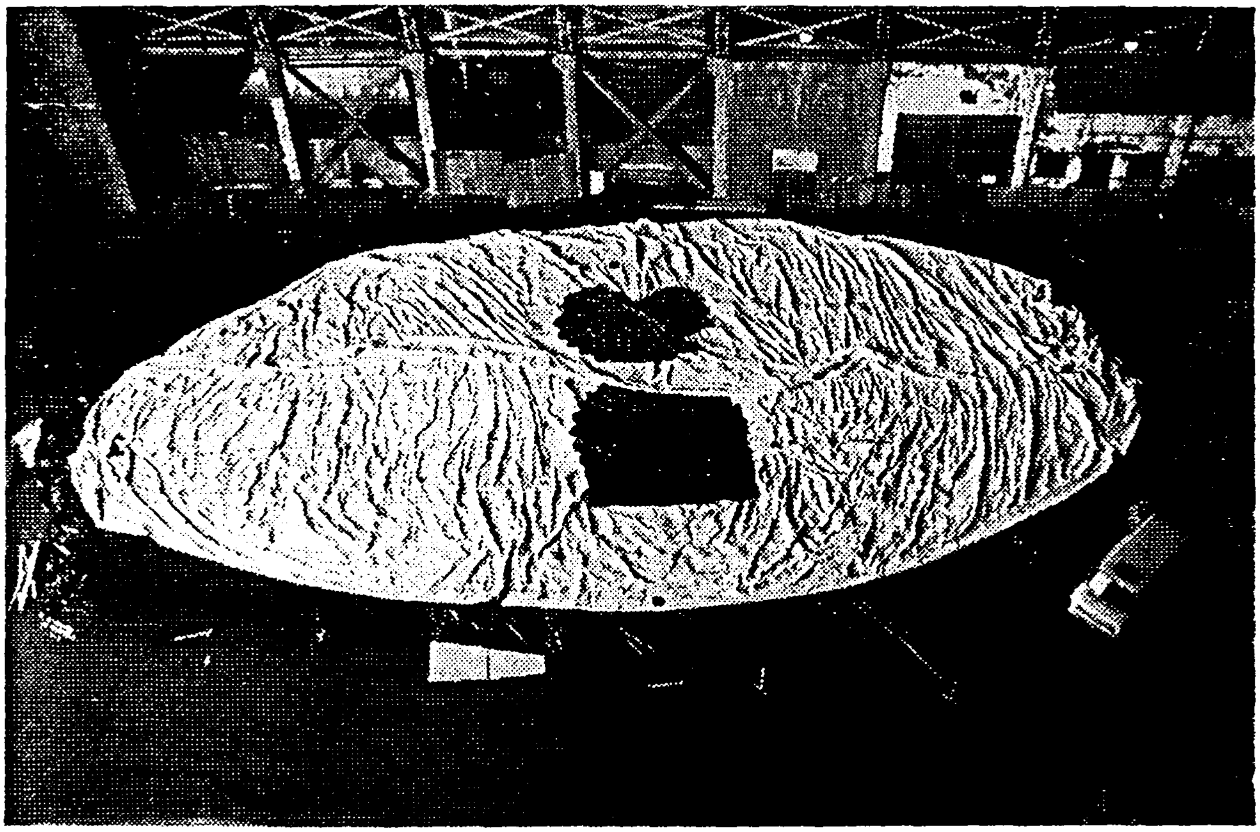


Figure 6. AEROSTAT.



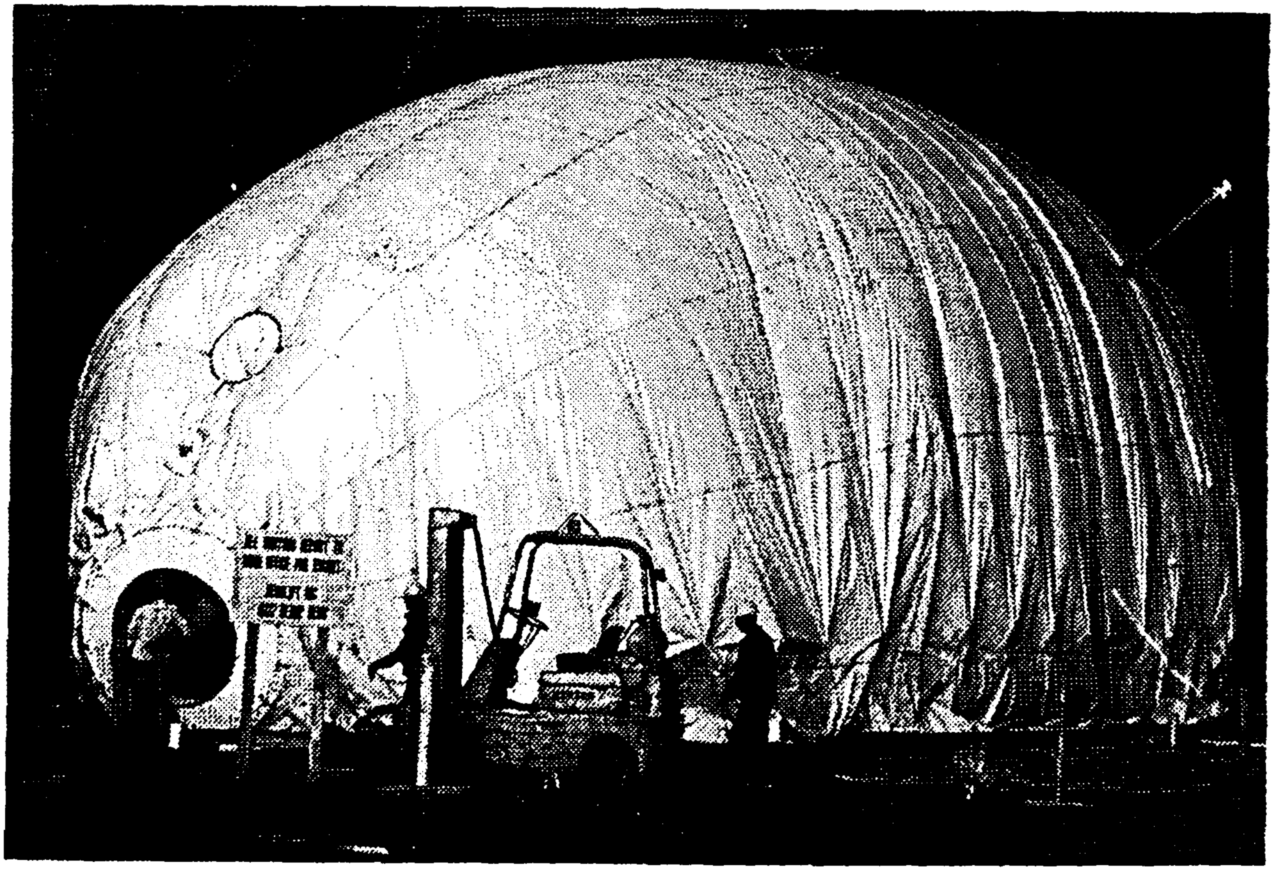


Figure 7.
FABRIC TUNNELS WITHIN THE AEROSTAT.

Figure 8.
BALLONET (OPERATES ALONG CENTERLINE TUBING).

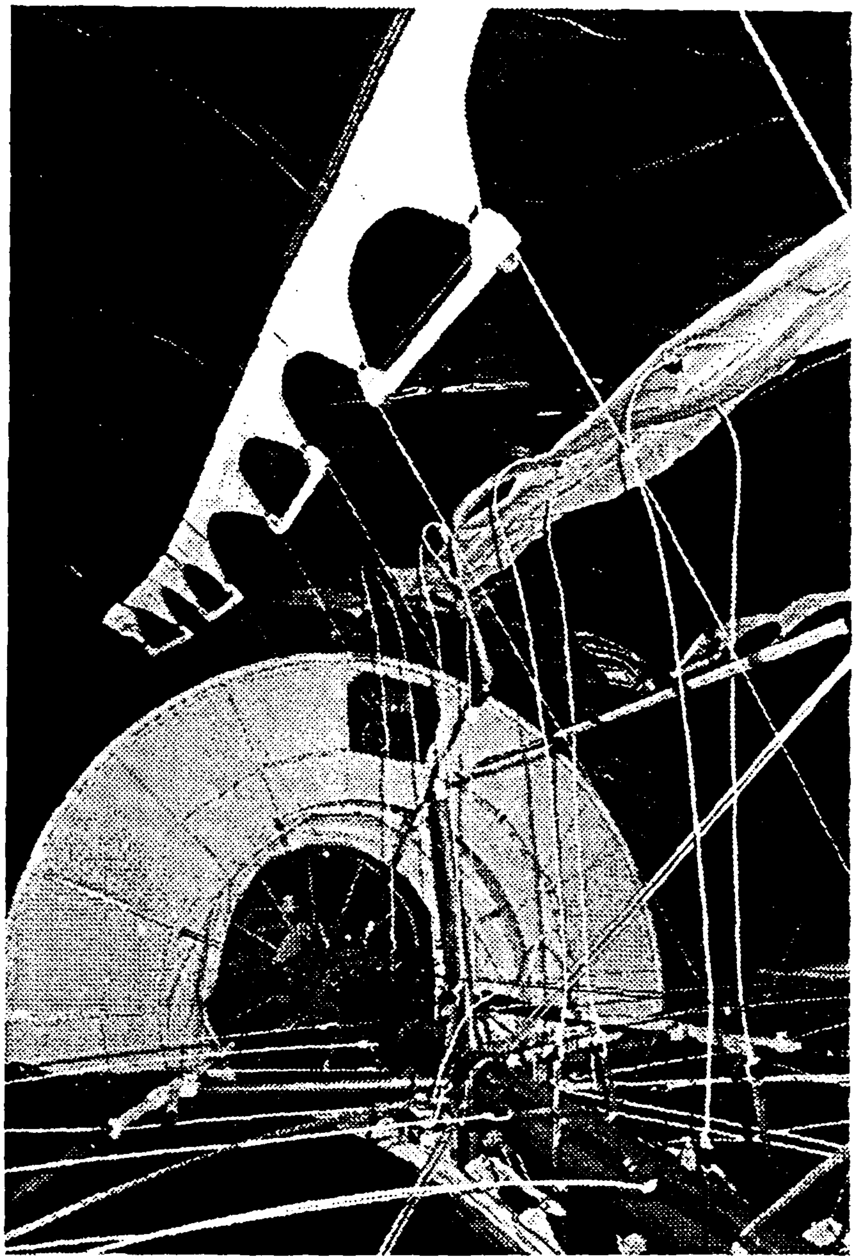
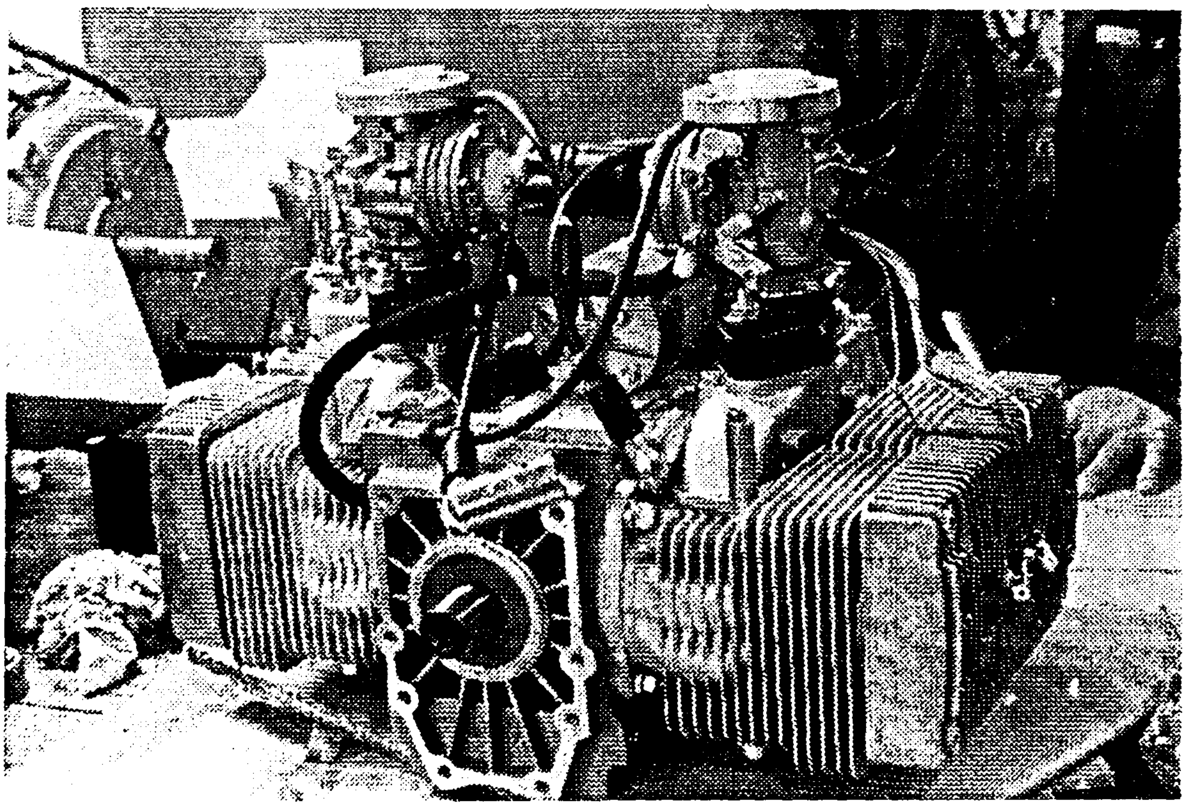


Figure 9.
HIRTH F-30 110 HP 2-STROKE ENGINE.



A unique system feature is that of data validation wherein each message or "data frame" is checked for errors upon receipt and prior to presentation as a system output. If, even a single error is detected, the erroneous frame is discarded and the previously received correct frame is again presented as system output and a signal is sent to the external systems to indicate that data is no longer being updated. As soon as any error-free frame is received, it will be presented as a system output. This feature allows the system to operate under adverse conditions where the RF signal is thresholding or interference is being encountered without fear of incorrect commands being transmitted.

The system is to be powered by 28 volts. Current drain at each end of the system will be approximately 4 amperes.

Discrete inputs are optically isolated and require a 28 volt DC signal. Input impedance is 2400 ohms. Discrete outputs are also optically isolated and are capable of sinking up to .5 ampere at 28 volts.

Analog inputs are 0 to plus or minus 5 volts, and input impedance is 10 megohms. Outputs are also 0 to plus or minus 5 volts (see Flow Diagram/Schematic in **Figure 10**, following this page).

RF transmission is in the 1710 - 1850 MHZ band which is allocated for government services and is administered by DOD. Transmitter output power is 5 watts and receiver threshold is -95 db. Assuming path loss of 80 db between upper and lower cab, the net link gain is in excess of that required to provide suitable signal strength. If the aircraft is operated with the crew cabin remaining on the ground, it would be possible to achieve at least a range of three miles between the crew cabin and the aircraft. Excess gain at this range is 20 db, a margin which is considered to be quite comfortable.

The telemetry equipment which is being manufactured by AACOM for AeroLift is identical to that which is currently flying on a number of remotely piloted aircraft. Consequently, this system has a history of usage in this application with minor modifications.

Figure 10. TELEMETRY FLOW DIAGRAM SCHEMATIC.

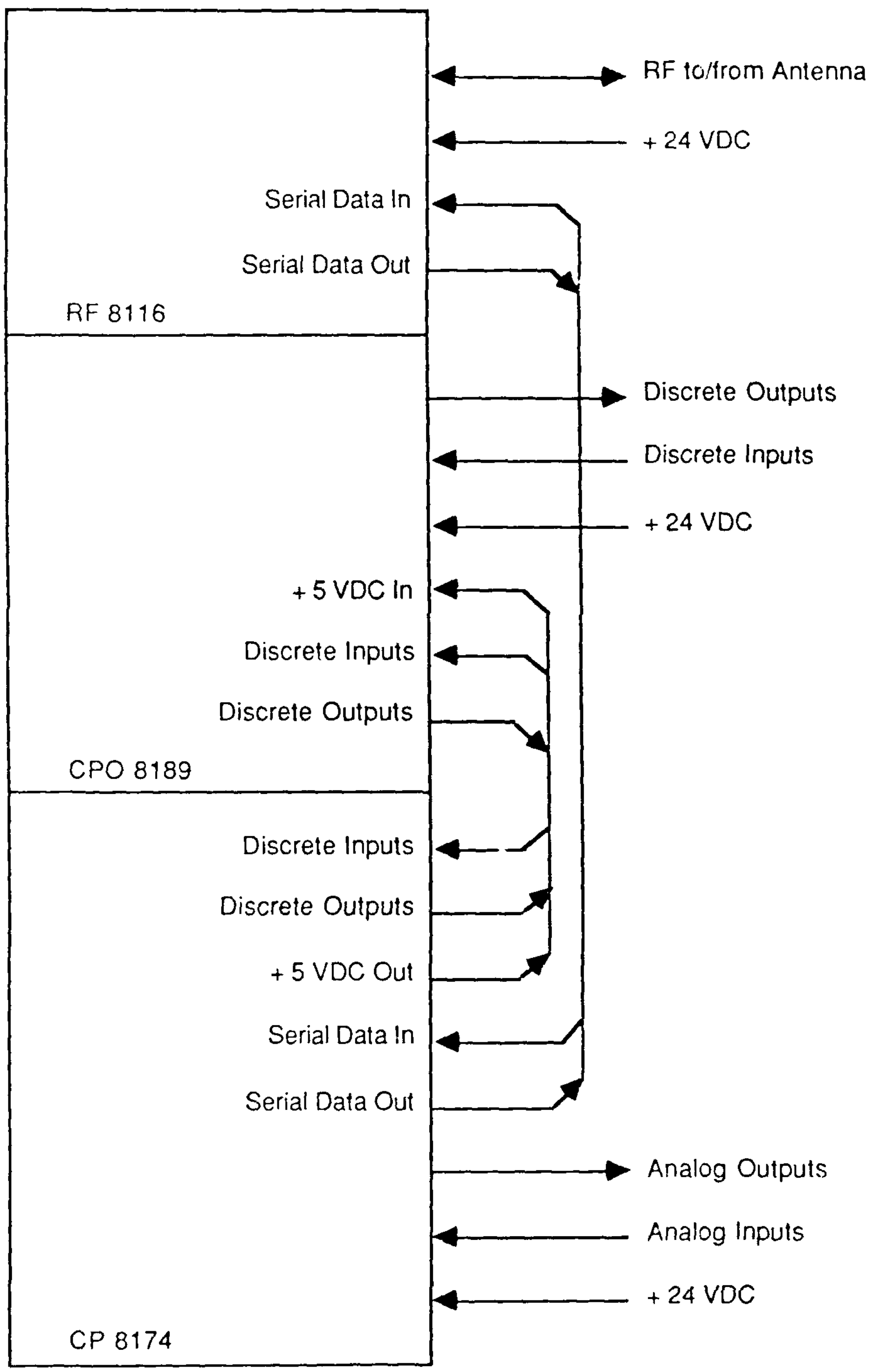
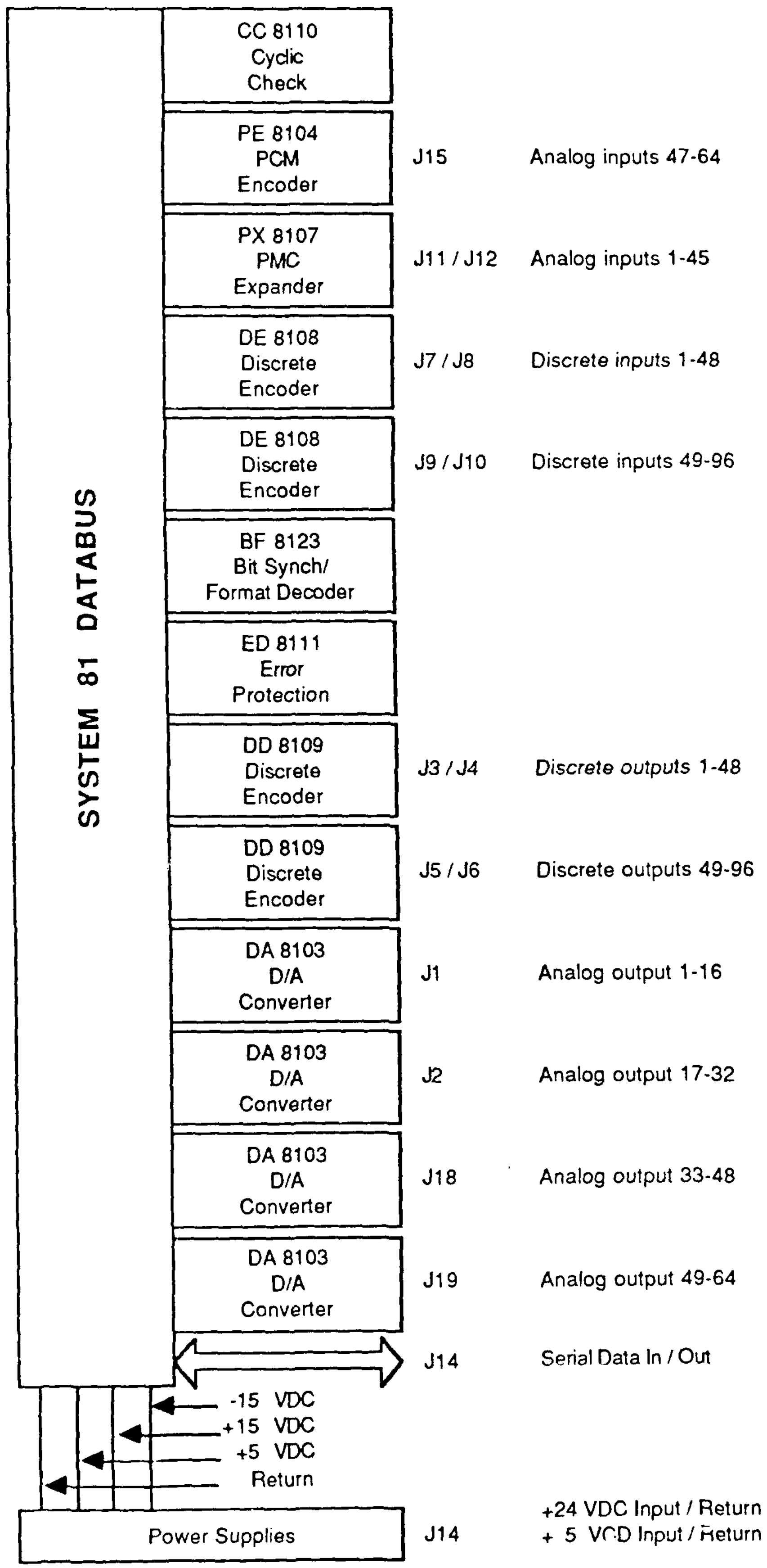


Figure 10. TELEMETRY FLOW DIAGRAM SCHEMATIC.



Power Distribution Subsystem

Additional electrical hardware was required to accommodate the installation of four engines in place of the original two. A gel cell battery has been installed in the new crew cabin.

With four engines operating concurrently, the regeneration of electrical power is designed to support a continuous consumption in excess of 200 amperes.

During preparations for tests, the power demand of ground handling operations is supported by an auxiliary power supply. This supply is to be mounted on the platform attached to the crew cabin. This power source is to support in excess of 50 amperes of remote consumption through a "jacked up" voltage regulator to avoid overcharging the small crew cabin battery as well as protecting against depletion because of demands. A voltage drop and drain blocking diode separation is mounted in the crew cabin near the generating source.

Tail

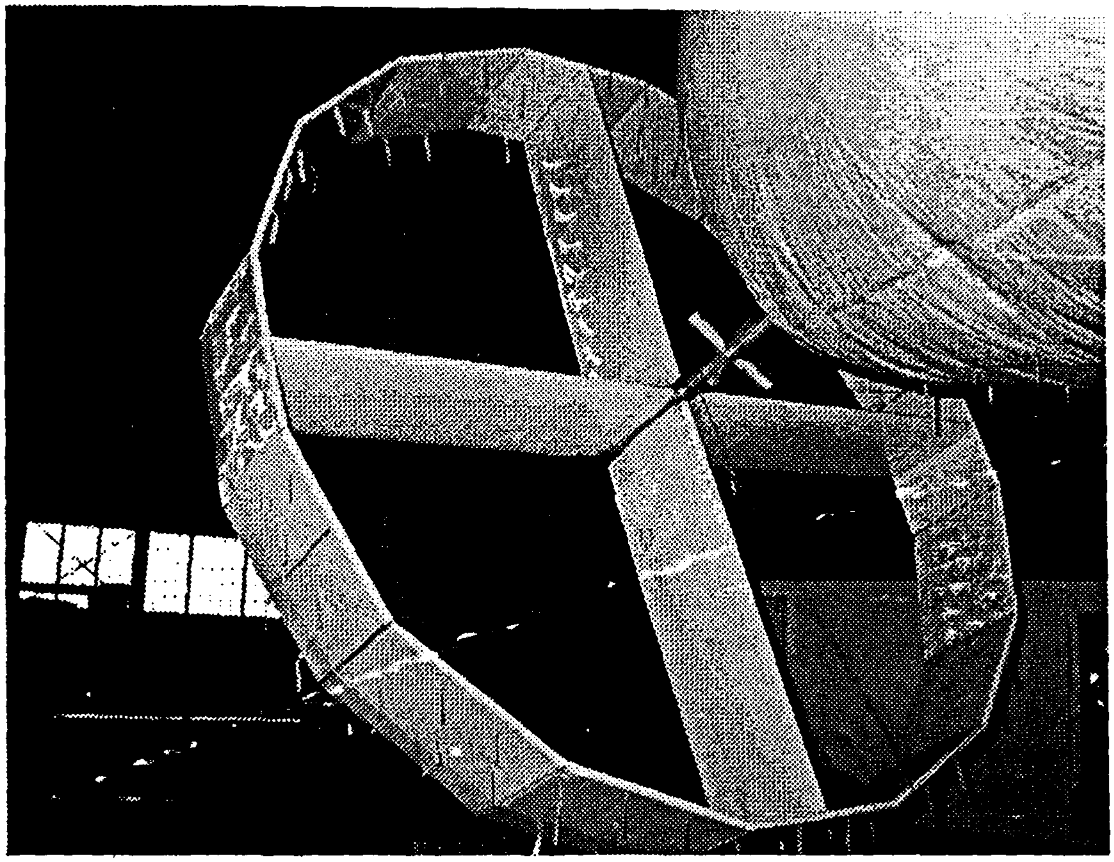
As a result of the 36 foot model tether test, it has been determined that the optimum configuration for maximum stability for the X.2 aircraft, when in a flight tether mode, requires additional aerodynamic surfaces within the ring-tail (a ring with a "plus" configuration). Some preliminary evaluations indicate that the "plus" might be replaced by an inverted "Y" or a single vertical cross-member. This will be verified in early 36 foot model ground handling tests (Test T1 in this Plan). If these weight saving configurations do not prove to be as efficient during these tests, AeroLift will proceed with the ring and plus tail on the X.2 aircraft (see **Figure 11**, following this page).

Crew Cabin (Lower Cab)

A UH-1M helicopter (furnished GFE) has been modified to accept the required instrumentation and control modifications (see **Figure 12**). The tail boom of this helicopter has been removed and modifications have been made to adapt the cockpit and the crew compartment to the X.2 CycloCrane. This new crew cabin has been modified to perform dual missions: (1) being slung below the X.2 CycloCrane as the crew cabin, and (2) being completely detached and acting

Figure 11. 36 FOOT MOORING MODEL TAILS.

(TOP: "RING AND PLUS" BOTTOM: RING AND INVERTED "Y")



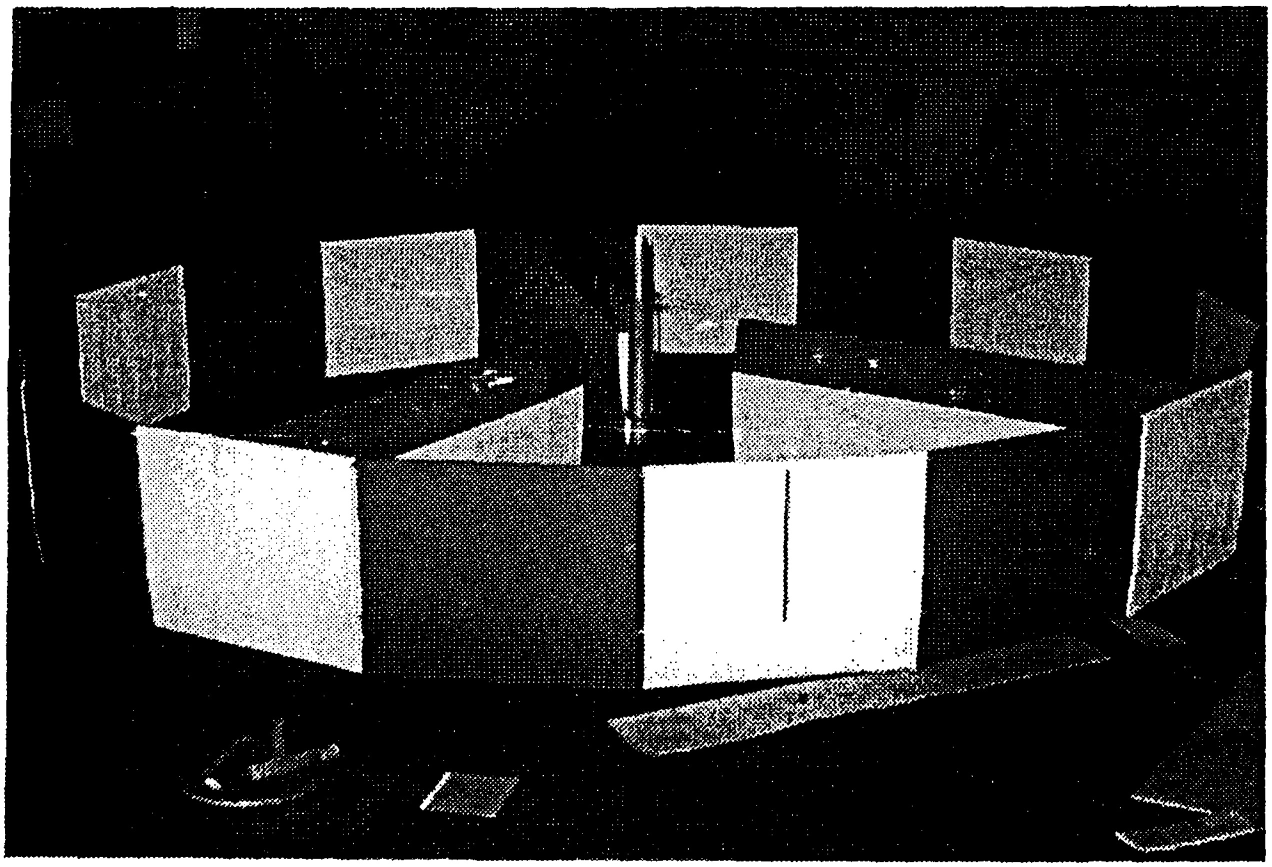


Figure 12.
UH-1M CREW CABIN IN PROCESS OF BEING MODIFIED.

as a control station on the ground for remote control operation.

Most instrumentation is modular. The modules can be disconnected with cannon plugs for ease of operation. This modularity serves a three-fold purpose: (1) they can be rearranged or changed to match crew compatibility and specific requirements for a given mission, (2) as a means of simplifying testing and troubleshooting from the engineer and technician standpoint, and (3) instruments can be selected to provide data acquisition signals.

The flight crew controls and instrument panel have been modified with the objective of maintaining a complete man/machine interface. The CycloCrane will be controlled in approximately the same manner as a helicopter as far as the cyclic stick, the collective stick and the anti-torque (yaw) pedals are concerned. This will allow an experienced helicopter pilot to transition into the CycloCrane with a minimum amount of flying time (see **Figure 13**, following this page).

<u>Ground Support Equipment (GSE)</u>

Paramount to the successful operations of hybrid aircraft are the GSE and handling methods used by the ground support crew. Since evaluation of the GSE and the ground support crew's method of operations are a major prime target of the limited flight tests, a brief discussion of the GSE is included here:

- **Helium Purification**

  The helium purification unit (see **Figure 14**) is considered to be state-of-the-art with respect to the methods used for helium purification today. A small amount of hydrogen (approximately 10%) is added to the helium in the aerostat. This mixture is then withdrawn from the aerostat and passed through a catalytic reaction chamber. Water, produced as a result of this process, is extracted. This removes one of the major contaminates of helium (oxygen). The remaining gas is then forced through a series of four permeable membranes which extract nitrogen from the mixture. The helium that remains is then returned to the aerostat. This

Figure 13.
HELICOPTER TYPE CONTROLS.

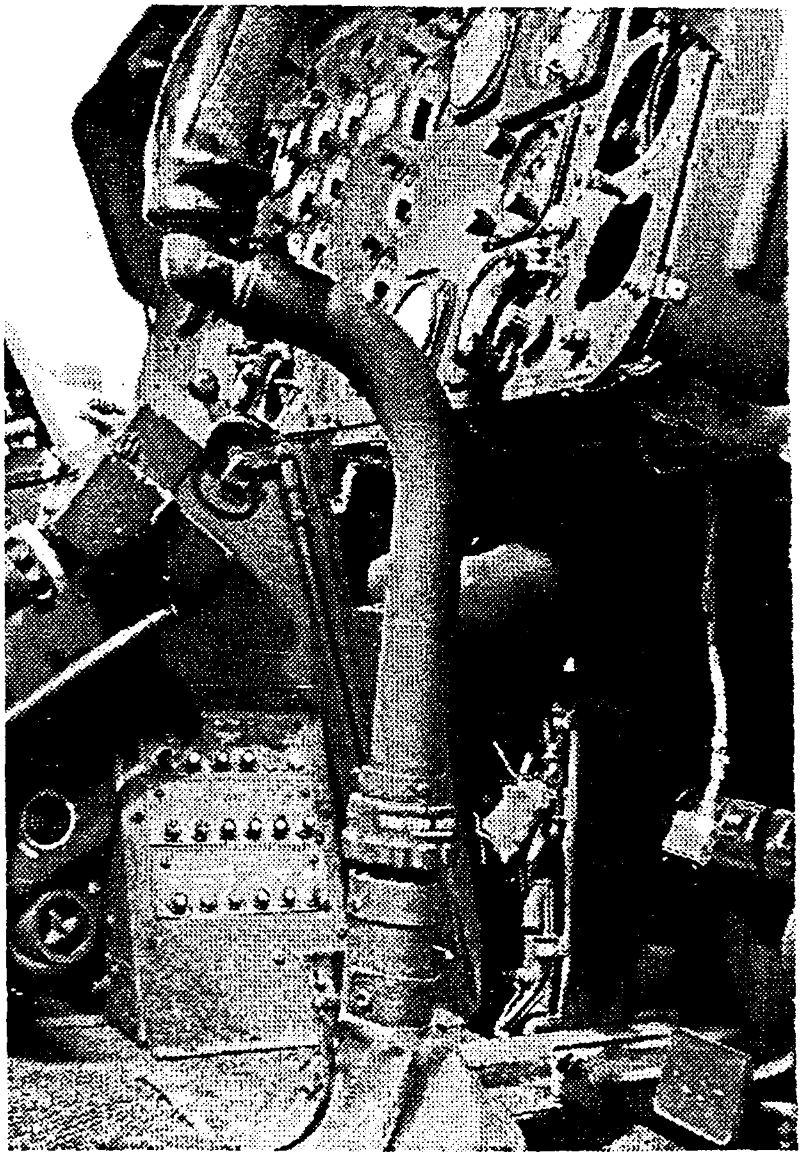
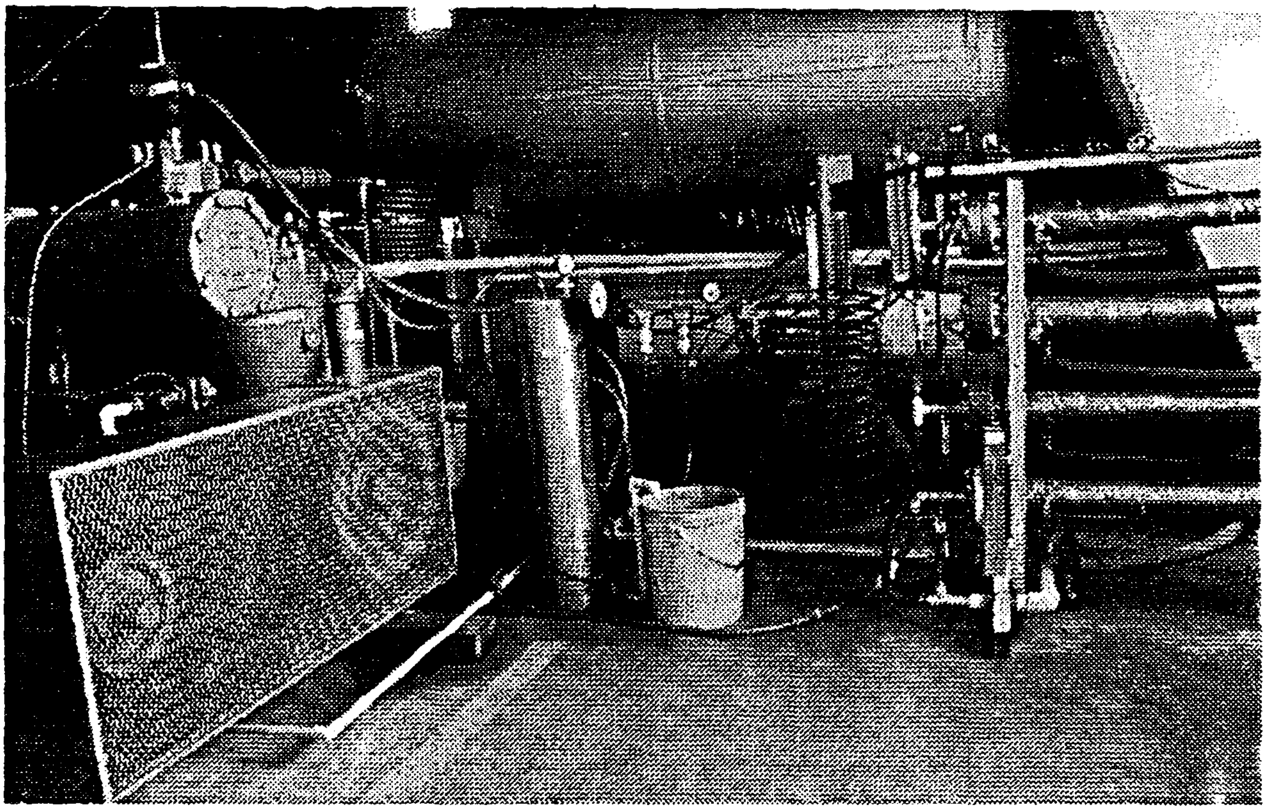


Figure 14.
HELIUM PURIFICATION SYSTEM.



helium is 99.5% pure. The entire aerostat can be purified to approximately 99% pure within ten full days of operation.

- **Mississippi Road Service Vehicles (MRS)**

AeroLift anticipates that the MRS vehicles are excellent candidates for use in ground handling the aircraft (see **Figure 15**, following this page). These vehicles, formerly used by the Seabees have been furnished to AeroLift as GFE. The major attributes of these vehicles for use as GSE are: (1) their size to weight ratio (approximately 39,000 pounds each), (2) the independent front and rear steering allowing extremely short turning radius, (3) their many attachment points that can be used to secure lines or attach winches, and (4) their rough terrain capability.

- **Mobile Mooring Mast**

The mobile mooring mast was designed and constructed by AeroLift and was used in previous testing (see **Figure 16**). One major objective in this system test program is to determine if this mast can be eliminated as part of the ground handling equipment. The mast does, however, facilitate the current ground handling operations and allows the aircraft to vector itself into the wind while maintaining a somewhat rigid system structure. It is 70 feet high when the aircraft is positioned in the "X" position with the stalk support dollies attached and can be telescoped to 90 feet to allow the vehicle to rotate and clear the ground or be positioned in the "+" position.

- **Stalk Dollies**

The stalk support dollies are used during the ground handling exercises to maximize the use of the aircraft's strong internal structure to provide stability to the aircraft in high winds when moored to the mobile mast (see **Figure 17**). They are attached to the lower two stalks when the aircraft is in the "X" position. They also allow the aircraft to vector itself

Figure 15. MRS GROUND HANDLING VEHICLE.

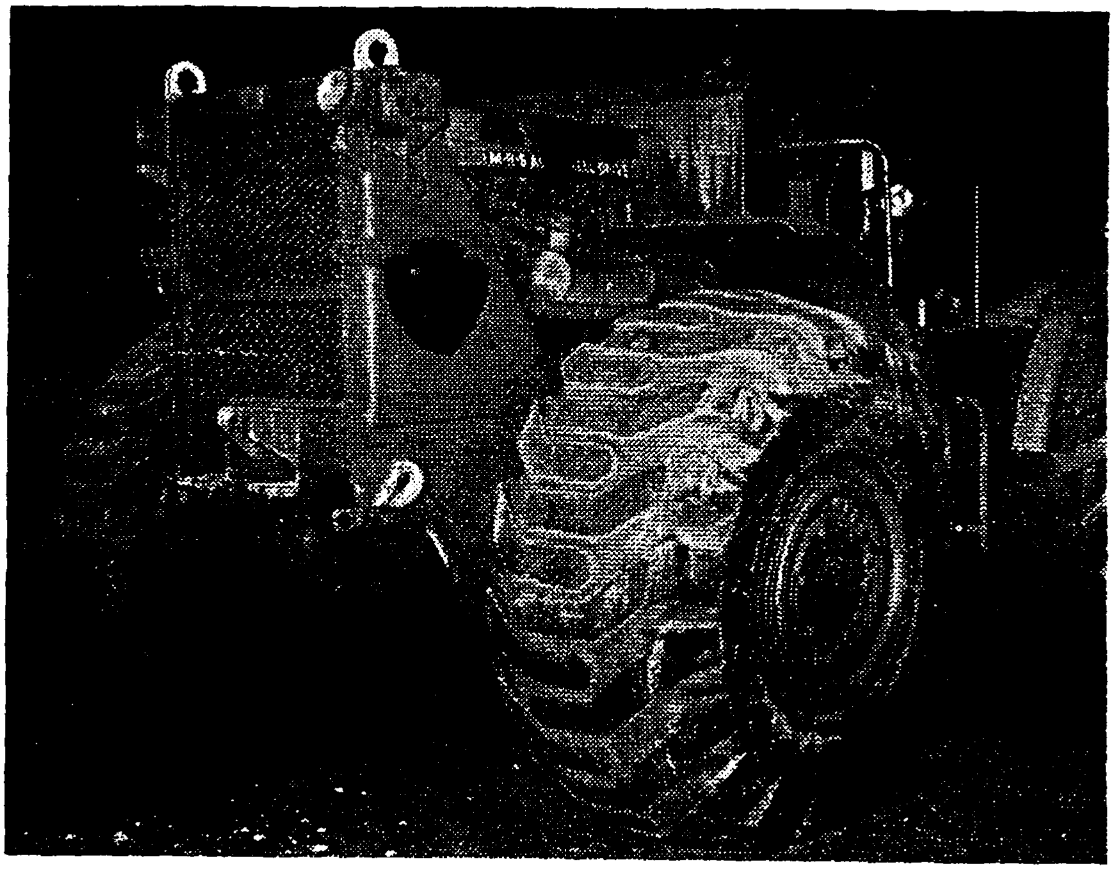


Figure 16.
MOBILE MOORING MAST.

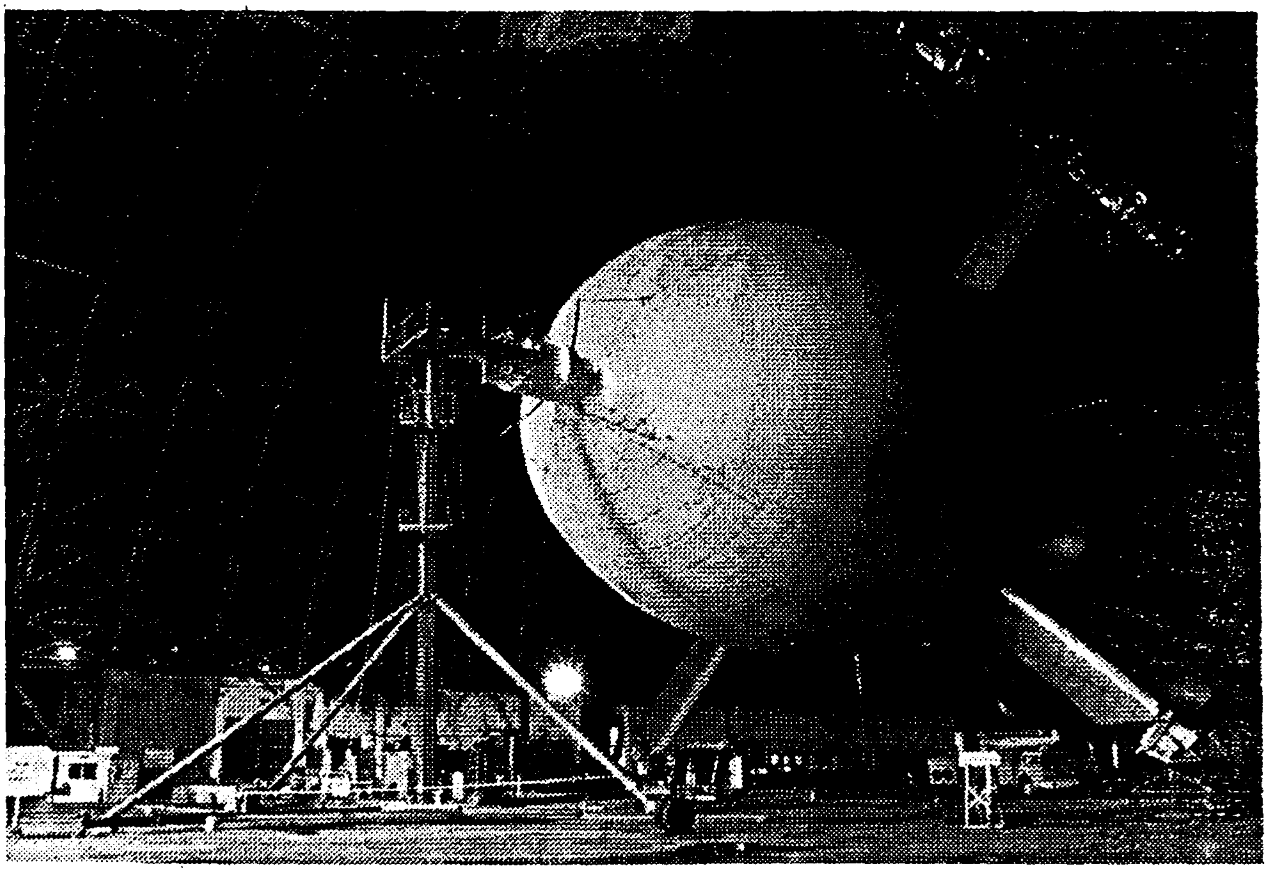
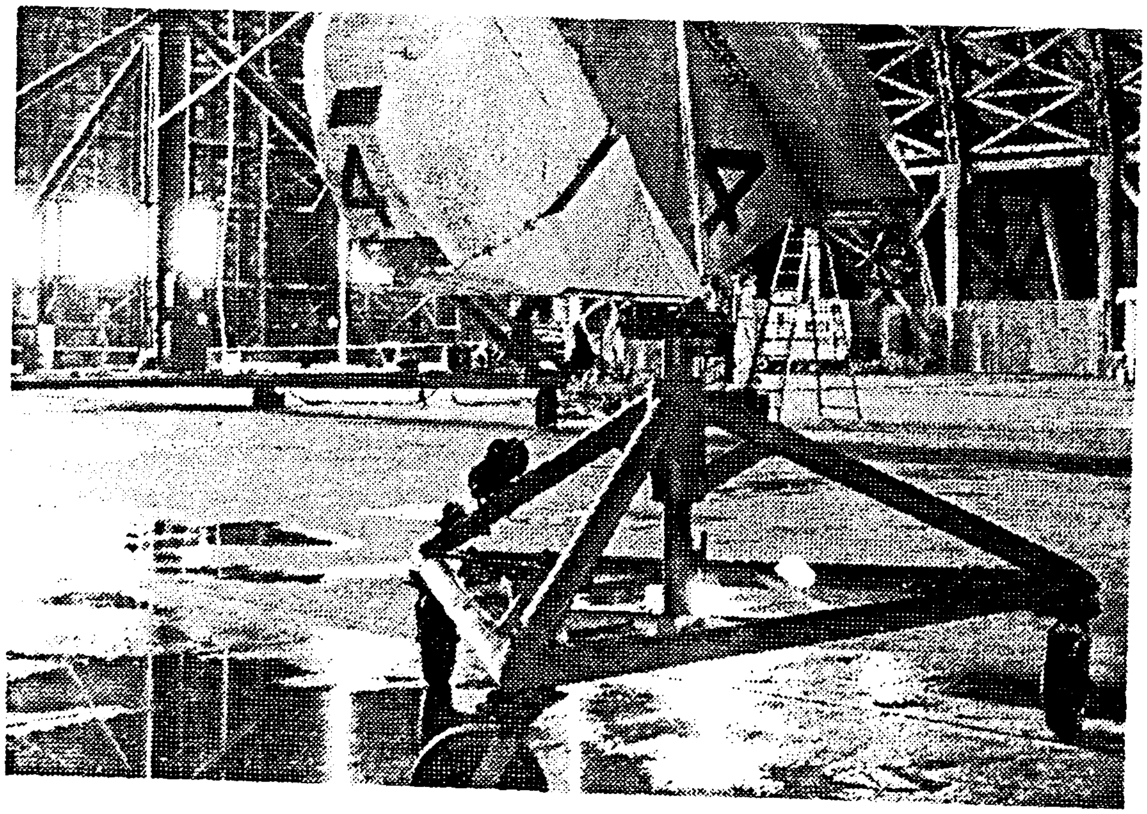


Figure 17.
STALK SUPPORT DOLLIES.



into the wind.

- **Tail Winch Trucks**

  The tail winch trucks (**Figure 18**, following this page) are used primarily to insure that the tail can be guided in the proper direction when transporting the aircraft to another point on the ground when crosswinds occur. These are pick-up trucks with winches mounted in the bed and through handling lines to the aircraft control the direction of the tail.

- **Tail Ballast**

  The tail ballast was designed and constructed by AeroLift (see **Figure 19**). It is primarily a water tank on dollies that can swivel and, if given the proper amount of water, keeps the tail from being too light, since the nose is attached to the mobile mooring mast. In addition, its weight assists the tail winch trucks to maintain directional control of the aircraft while being towed on the ground.

- **Lower Cab Transporter**

  The lower cab transporter (see **Figure 20**) was designed and built by AeroLift as a means of transporting the crew cabin to a ground position prior to launch of the aircraft or upon the retrieval of the aircraft.

- <u>36 FOOT CYCLOCRANE MODEL</u>

The general arrangement for the 36 foot CycloCrane model with baseline tail configuration that will be used for Test T1 is presented in **Figure 21**. Its size corresponds to 21.4% of the X.2 aircraft. The model is designed to simulate static lift in mooring exercises as well as ground handling characteristics. Its overall length is 48 feet with a rotor diameter of 37 feet 8 inches. The aerostat is 36 feet long and has a maximum diameter of 18 feet (see **Figure 22**). For analysis purposes, it is approximated by a 2:1 prolate ellipsoid in projection. Specifications of the airfoil sections of the wings, blades, and tail are provided in Table 1.

Figure 18.
TAIL WINCH TRUCK.

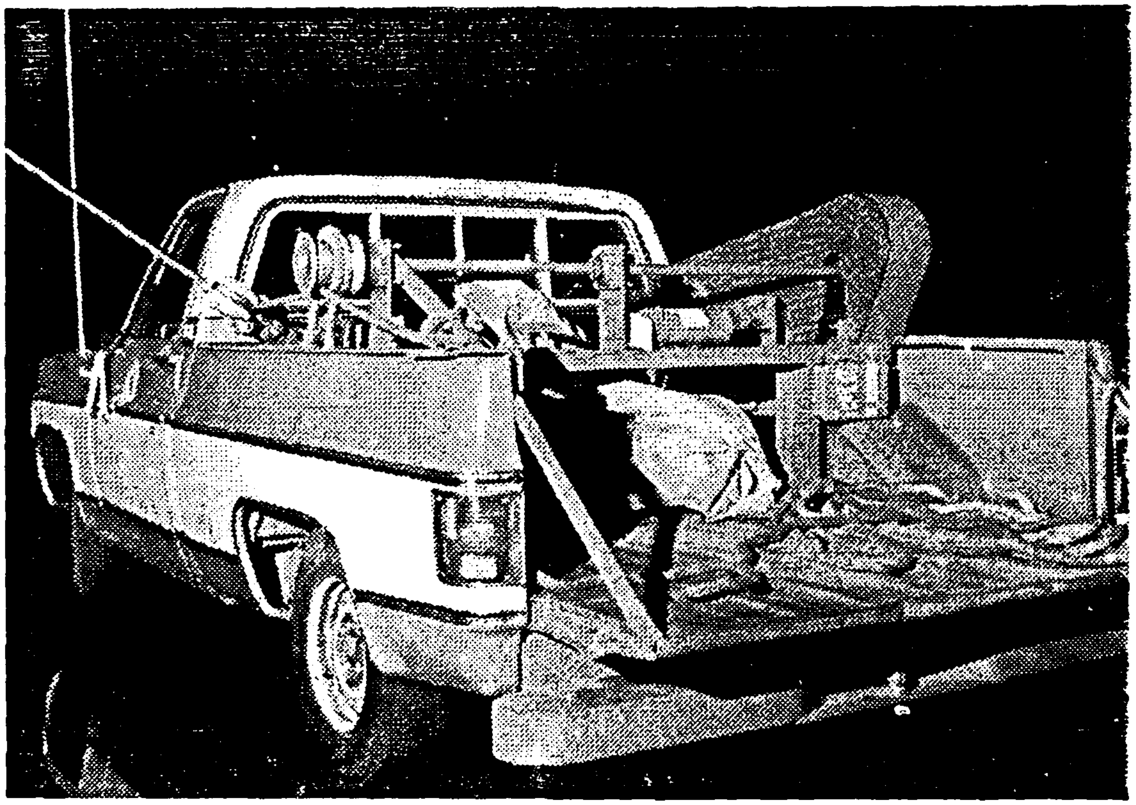


Figure 19.
TAIL BALLAST TANK.

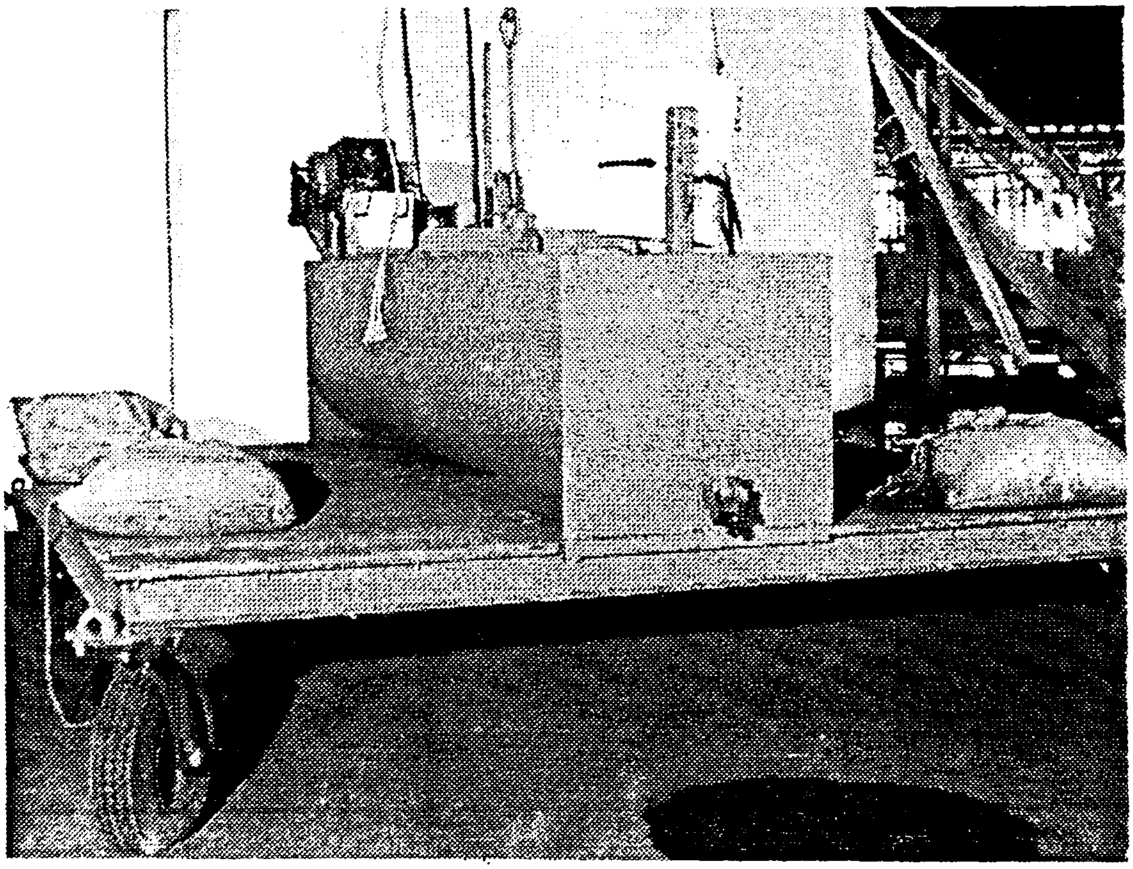


Figure 20.
LOWER CAB TRANSPORTER.

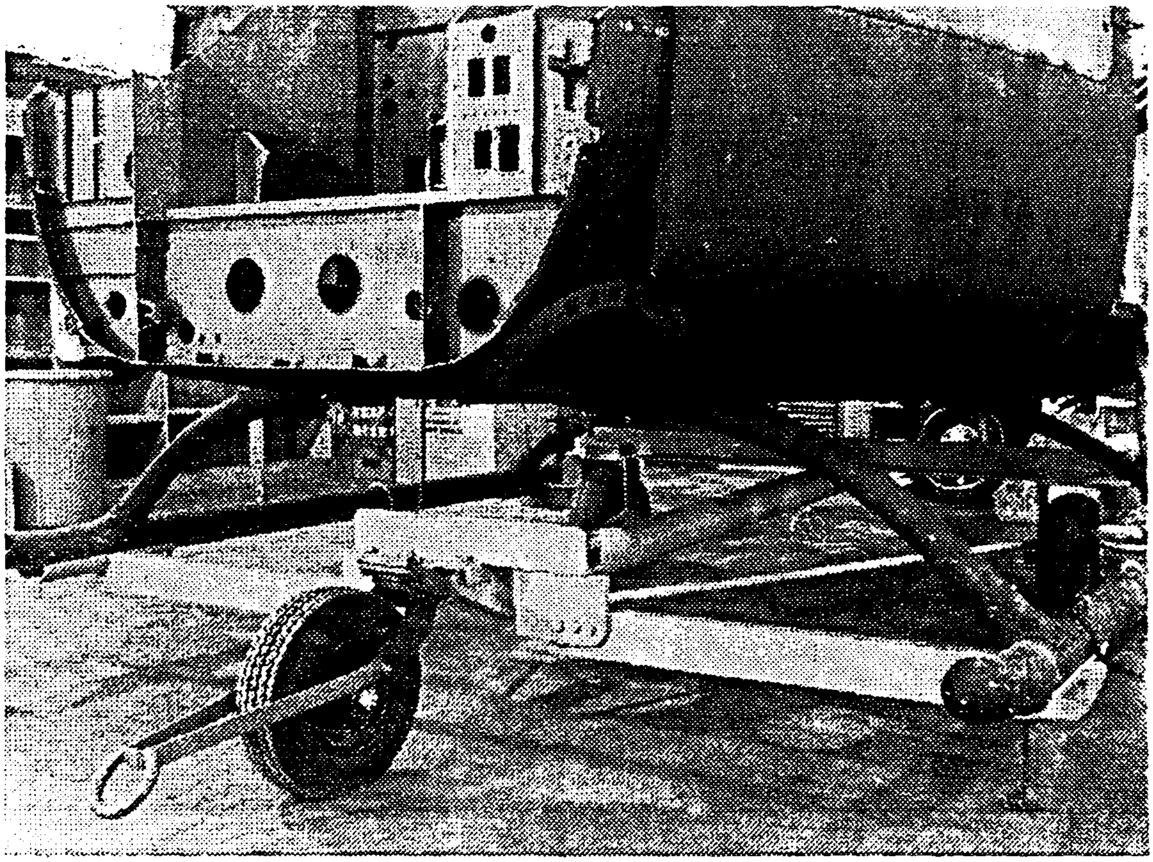


Figure 21. 36 FOOT MOORING MODEL GENERAL ARRANGEMENT

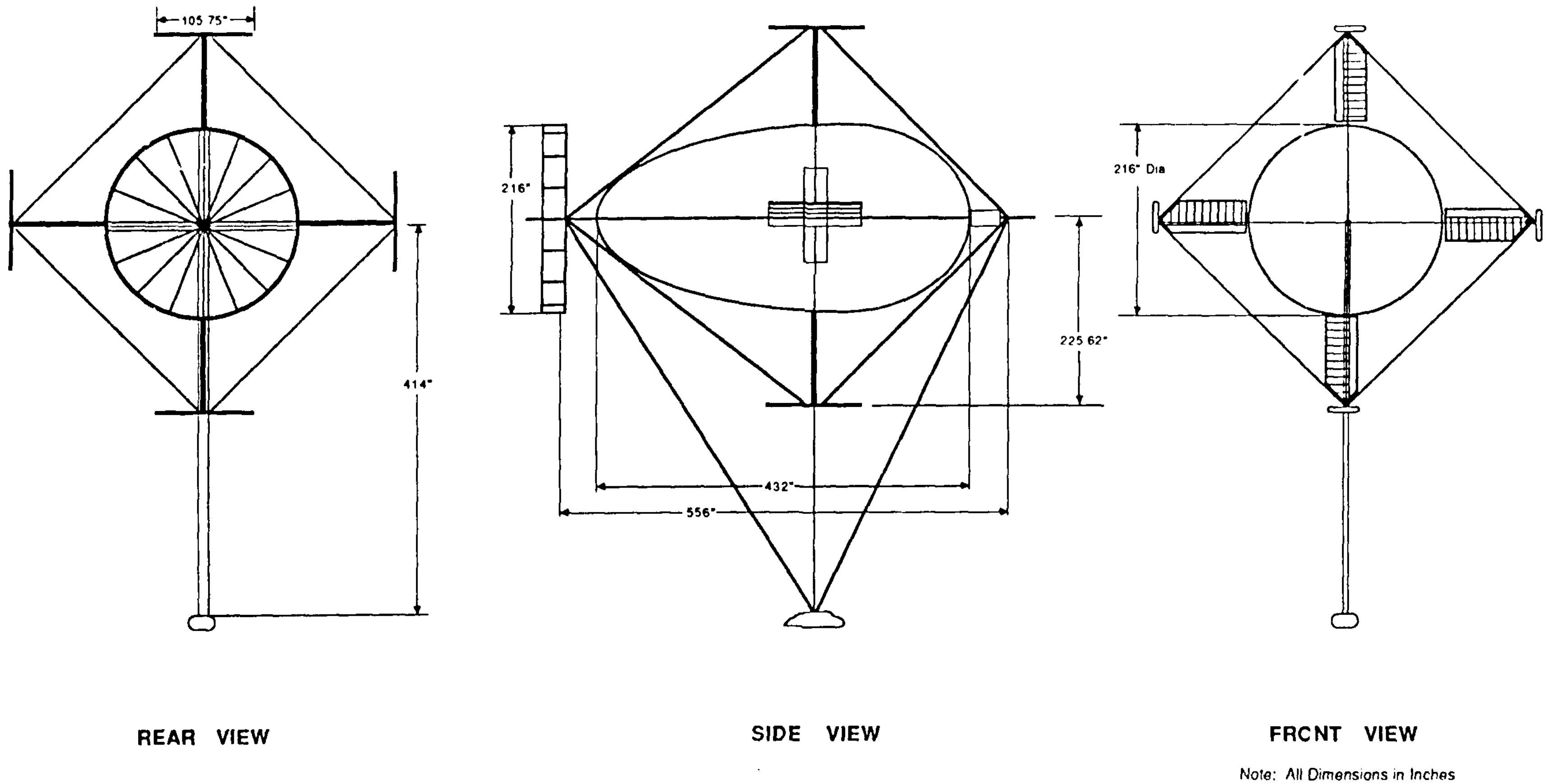


Figure 22.
36 FOOT MOORING MODEL.

TABLE 1

36 FOOT CYCLOCRANE MODEL AERODYNAMIC SURFACE SPECIFICATIONS

COMPONENT	DIMENSIONS (INCHES)
Wings	
Span	105.75
Chord	24.25
Thickness	6.25
Aspect Ratio	4.36
Blades	
Span	95.50
Chord	24.25
Thickness	6.25
Aspect Ratio	3.94
Tail	
Chord	32.00
Thickness	1.63
Number of Panels	18
Diameter	216

Ground Support Equipment (GSE)

The GSE requirements for the ground handling exercises planned during Test T1 will be a mix of:

- Scaled down items such as the mobile masts and the stalk support dollies (these are being fabricated at AeroLift from common plumbing material)

- Full size items of equipment which are necessary for the scenario evaluations; e.g., MRS vehicles.

System Test T1

The above mentioned GSE along with the 36 foot model will be employed by AeroLift (as discussed in Section 2.0) to train personnel and evaluate ground handling scenarios. The range of scenarios will embrace repetition of the handling techniques employed in prior flight test activities and a number of other approaches that will vary the mix of equipment, personnel and tether options to determine those with the most potential for full evaluation in the X.2 test phases. This system test (Test T1) will be accomplished prior to initiation of the Flight Readiness Review.

5. SYSTEM TEST TASKS

5.0 SYSTEM TEST TASKS

The major tasks associated with the accomplishment of the system test program are the following:

- Flight Readiness Review (FRR)
- Training
- Safety
- System Tests
  - T1 36 Foot Model Ground Handling
  - T2 X.2 Ground Handling
  - T3 X.2 Tether Variations
  - T4 X.2 Data Acquisition
  - T5 X.2 Remote Operation
- Data Acquisition and Analysis
- Quick Look Reports
- Final Report.

These are discussed in the following sections.

5.1 Flight Readiness Review (FRR)

Prior to the initiation of the X.2 system test phases, AeroLift shall demonstrate to DARPA/Aerospace that the upgraded X.2 aircraft, the supporting hardware, and personnel are ready for such testing.

AeroLift proposes to accomplish the segmented FRR through execution of preflight checkout of subsystems in the hangar, briefings to flight test personnel on total operations, and actual rollout from the hangar to test area (with subsequent preparation up to the start position for the first X.2 test; e.g., Test T2 - X.2 Ground Handling).

In support of this scenario, Checklists will have been developed for aircraft and ground equipment subsystems, and ground handling procedures will have been developed subsequent

to the completion of Test T1 - 36 Foot Model Ground Handling (Appendix A presents example procedures).

The preflight checkouts are to assure functional readiness of the air and ground hardware. This is followed by personnel briefings on what the scenario entails, with the operation starting immediately following the briefing. During the pretest checks, the test personnel will implement a dry run of the complete set of Test Cards developed for the tests being planned (in the FRR case, this is Test T2 - X.2 Ground Handling). Beyond providing familiarity with test sequences, this also provides a nominal estimate of the test time that ...uld be required for actual execution. The basic ...mentation, including those items mentioned above, are ...ng developed into general categories, as follows:

- Ground Handling Procecures
- Pre and Post Flight Procedures
- Data Calibration, Checkout and Acquisition Procedures
- Emergency Procedures
- Pre and Post Flight Briefings
- Weight and Balance Data.

...perations are straightforward, while realistic ...rations of abnormal or emergency situations require ...rable thought. Beginning with Test T1 - 36 Foot Model ...d Handling, AeroLift personnel will conduct a continuing ...logue on "What If" situations during ground handling or ...r operations; e.g., what if a mast tire blows out, a tow ...k fails, a ground handling line breaks or unexpected winds ...r. This dialogue also will be continuing between AeroLift ... ARPA/Aerospace personnel.

...intent by AeroLift is to document those emergency ...ions that have the potential of occurring and that would ... issues for personnel and/or hardware. Such ... would be inherent to test crew briefing ... ry run activities.

...ance by DARPA/Aerospace of the total FRR phases, ... proceed with the stipulated system test

5.2 Training

As noted in Section 3.0, System Test Schedule, AeroLift plans to provide extensive training for system test personnel by use of the 36 foot model in conjunction with companion GSE; e.g., scaled down mobile mast and stalk support dollies, and the tractors recently acquired as GFE. Further, personnel training will evolve through development of system Checklists, briefings, pretest and post test procedures and the Flight Readiness Review segments (see **Figure 23**, following this page).

For those system tests which require operation of the X.2, flight crew training was achieved to a large degree through previous flight tests, and will be enhanced in this program through development of Test Cards (updated for hardware modifications and scope of planned tests), coupled with dry runs in the lower cab. Further training will occur during powered X.2 phases in Test T3 through T5.

5.3 Safety

A single qualified engineer and an alternate at AeroLift will be designated as the Safety Officer. The safety officer will have the authority to cease any activity during system test operations that could cause potential problems.

Many of the safety aspects are addressed in emergency procedures and "What If" exercises that were discussed previously in Section 5.1, Flight Readiness Review (FRR). However, one prevailing safety aspect is the weather during system tests; e.g., wind. Recognizing its importance, a specific ground rule (noted in Section 2.0, Ground Rules) prevents any attempts to exit the hangar with the X.2 when winds are measured to be greater than 15 mph (crosswind component). In addition to its own weather reporting station (see example on **Figure 24**), AeroLift currently has arrangements with:

- <u>KTIL Radio Station</u> - Located four miles northwest of test site. Used for real time wind direction and speed projections

- <u>United States Coast Guard</u> - Located in Astoria, Oregon. Used for 30 minute predictions

- <u>Tillamook Airport</u> - Adjacent to the test site and used for real time wind direction and speed projections

Figure 23 GROUND CREW TRAINING.

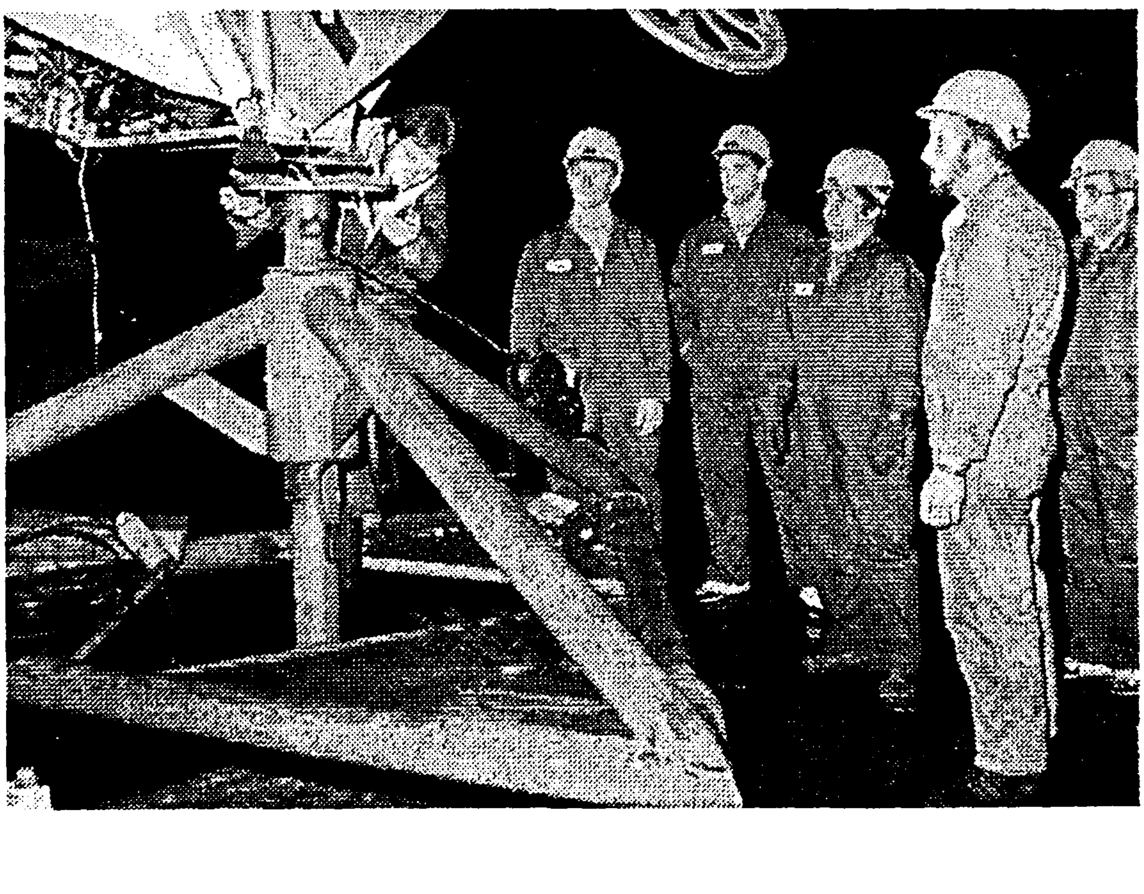


FIGURE 24

[illegible]	[illegible]	[illegible]	TEMP	[illegible]	SPEED	GUST	DIRECTION	[illegible]
	[illegible]	F	F	[illegible]	MPH	MPH	DEGREES	IN.
[illegible]	[illegible]	[illegible]	56.?	[illegible]	0	0	90	0.0
[illegible]	[illegible]	?.5	?.2	??.5	0	0	90	0.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	24?	0.0
[illegible]	[illegible]	[illegible]	?.2	[illegible]	0	0	225	0.0
1:00a	[illegible]	?1.9	56.1	?1.9	0	0	180	0.0
?:00a	??.99	33.3	56.1	??.3	0	0	157	0.0
[illegible]	[illegible]	[illegible]	56.?	[illegible]	0	0	45	[illegible]
?:00a	[illegible]	?4.?	?.0	?4.?	0	0	360	0.0
4:0?a	[illegible]	?.4	56.0	?.4	0	1	180	0.0
4:30a	[illegible]	?.6	56.1	[illegible]	0	0	67	0.0
5:00a	[illegible]	[illegible]	56.0	[illegible]	0	0	67	0.0
5:30a	[illegible]	[illegible]	56.1	?.?	0	0	67	0.0
6:00a	?.6?	[illegible]	56.0	[illegible]	0	0	67	0.0
[illegible]	[illegible]	[illegible]	56.0	[illegible]	0	0	112	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	15?	[illegible]
[illegible]	[illegible]	[illegible]	?.1	[illegible]	0	0	1??	[illegible]
?:00a	[illegible]	[illegible]	56.1	[illegible]	0	2	180	[illegible]
[illegible]	[illegible]	[illegible]	56.?	[illegible]	1	3	13?	[illegible]
[illegible]	[illegible]	[illegible]	56.?	[illegible]	1	4	112	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	157	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	5	157	[illegible]
[illegible]	[illegible]	4?.?	57.	[illegible]	0	0	120	[illegible]
[illegible]	[illegible]	?.?	?.?	[illegible]	0	4	[illegible]	[illegible]
LOWEST	[illegible]	31.6	55.0	?1.6	0	0	45	0.0
TIME	[illegible]	?:14a	7:40a	[illegible]	10:59a	10:59a	3:59a	10:56a
HIGHEST	[illegible]	44.7	57.?	44.?	5	5	360	0.?
TIME	[illegible]	10:10?	10:5?	[illegible]	10:18a	10:18a	4:08a	[illegible]
AVERAGE	[illegible]	41.?	57.?	[illegible]	0	1	1?1	[illegible]

- Bureau of Land Management - Adjacent to test site. Used for speed projections.

During test operations, AeroLift has obtained support from the Tillamook City Rural Fire Protection District for an on-site fire truck and an emergency medical team from the Tillamook County General Hospital for an on-site ambulance in the event of an emergency.

5.4 System Tests

As noted in **Figure 1**, there are a series of five system tests (T1 through T5), with Test T1, discussed previously, being the 36 foot model evaluation that terminates just prior to the start of the final FRR segment of full X.2 demonstration. Upon completion, and approval of the FRR segment by DARPA/Aerospace, AeroLift shall initiate Test T2 - X.2 Ground Handling.

Details of all planned system tests; e.g., specific sequential steps on Checklists/Test Cards, are to be developed prior to the initiation of a particular system test phase (Appendices B and C illustrates examples of Checklists and Test Card data). Brief descriptions of the planned activities in Test T2 through T5 are presented in the following:

Test T2 - X.2 Ground Handling

Based on the results of the 36 foot model ground handling exercises, the preferred approach will be used in this system test phase involving the nonpowered X.2 aircraft and associated GSE. That scenario will be detailed in specific sequential steps on the Checklists/Test Cards.

It is expected that certain differences; e.g., scale or specific hardware of 36 foot versus the X.2, may require alteration of the preferred scenario prior to execution of the test. After appropriate documentation has been completed, incorporated in the final FRR segment and successfully demonstrated in that segment, AeroLift shall then execute Test T2 in its entirety. A nominal amount of instrumentation; e.g., measure static lift, is required for this test. However, AeroLift will include an assessment of the preferred scenario as it relates to the overall mix of hardware and personnel in the Quick Look Report. Video coverage will be provided of actual flight test execution.

Test T3 - X.2 Tether Variations

This series of tests involve:

- A validation, or not, of the scaleableness of the successful single tether test on the 36 foot model to the full X.2 aircraft, and

- Extension of tether considerations beyond single-line, nonpowered X.2 conditions.

For the first item, the X.2 CycloCrane will be tethered on a 1,000 foot line (previously delineated scale-up length in the 36 foot model tethered test report of July 29, 1988) and its stability assessed under the same static and dynamic conditions that were imposed on the 36 foot model (see same report). If stability is achieved, it will demonstrate that scale factors are correct. If not, modifications would be required to the X.2 to achieve desired levels of stability.

After this phase, a number of tether related variations will be executed and their relative worth determined. These tests will involve:

- Different tether line lengths

- Different tether line attachments; e.g., harness arrangements

- Multiple tether line approaches.

The resultant evaluations will determine a preferred tether line(s) configuration.

It is then planned to assess what improvements; e.g., in level of stability or ability to withstand higher winds, might be gained by presetting angles of aerodynamic surfaces (blades, wings, or stalks). From these test phases, a preferred aerodynamic preset input will evolve.

Finally, with the preferred combination of tether line(s) and aerodynamic surface settings, the X.2 aircraft will be powered (at various rotation speeds from zero to full vehicle rpm) to determine if added benefits are achievable for stability in higher winds.

From these tests, a preferred combination (if any) of tether line(s), aerodynamic surface settings and power settings will evolve for specific stability or wind holding conditions.

For the preferred combination as indicated above, another area of variability also will be evaluated as to the potential for improving tethered operations in the field (increased static lift). This is assessed by increasing static lift through:

- Increased helium purity
- Super heating aerostat
- Possibly reducing "dead weight" of the aircraft by removing nonrelevant hardware.

As stated in Test T2, specific Checklists/Test Cards will be prepared and rehearsed by AeroLift prior to initiation of test phases with video coverage provided during test execution. Quick Look Reports will provide an overall evaluation of achieved results.

Test T4 - Data Acquisition

This system test series is directed toward the acquisition of data such as:

- Control power information on the new, four engine configuration
- Aerodynamic data relevant to needs of the parametric model utilized in the design development activities.

For these tests, the X.2 will be fully instrumented (tentative Master Measurement List shown in **Figure 25**, following this page) and will be powered while being fixed at both ends of the longitudinal axis between the existing fixed and mobile masts. This is essentially a replication of basic "Spin Rig" set-up that was employed earlier.

In the first series, control power will be assessed at different engine power settings. With the second series, hover power related factors will be determined through a number of wing input excursions at different power settings.

As in Test T2 and Test T3, video coverage will be provided during test executions and Checklists/Test Cards will be prepared in detail prior to initiation of test phases. The results of these tests will be presented in the Quick Look Reports.

Figure 25. MASTER MEASUREMENT LIST.

MEASUREMENT	SENSOR	SENSOR LOCATION
ENVIRONMENT		
Time	Clock	Ground
Wind	Anemometer	Ground
Humidity	Humistat	Ground
Ambient Pressure	Barometer	Ground
Ambient Air Temp	Thermometer	Ground
Precipitation	Rain Gage	Ground
AEROSTAT		
Helium Purity	Gas Chromatograph	Ground
Helium Pressure (Ambient)	Dif Press/DP Cell	Ballonet
Superheat Temp	Thermistor (delta temp)	Aerostat
Ballonet Fullness	Potentiometer	Plenum
Ballonet Pressure	DP Cells	Ballonet
VEHICLE (STRUCTURE & DYNAMICS)		
Strain Gages	Strain Gages	Struct/Cbl
Airspeed (vehicle)	Pitot Tube	Lower Cab
Airspeed (wing)	Anemometer	Wings
Relative Wind	Vane/Pot	Wing #1
Angle of Attack	Vane/Pot	Wings 1&2
Rate of Climb-Descent	ABS Press Cell/ Variometer	Lower Cab
Altitude (altimeter)	ABS Press	Lower Cab
Angular Accel-Pitch	Accelerometer	Upper Cab
Angular Accel-Roll	Accelerometer	Upper Cab
Angular Accel-Yaw	Accelerometer	Upper Cab
Pitch Attitude	Gyro	
Roll Attitude	Gyro	Upper Cab
Yaw Attitude	North Seeker	Upper Cab
Direction (heading)	North Seeker	Upper Cab
Pitch Rate	Rate Gyro	Upper Cab
Yaw Rate	Rate Gryo	Upper Cab
Platform Rate-Roll	Rate Gryo	Upper Cab
Vehicle RPM	Veh Tach	Upper Cab
CycloCrane Motion	Video Camera	Ground
Aircraft Weight	Calc & Load Cell	–
Load Weight	Load Cell	Ground
Load Factor	Accel	Lower Cab
Crew Communications	Video Camera	Lower Cab
Ground Support Oprns	Visual	Ground
Flow Field (tufts)	Video Lateral	Ground
Payload	Video Longitudnl	Ground
Time	Time Code Gen	
Buoyancy (lift)	Load Cell	Lower Cab
ROTOR SYSTEM (BLADES & ENGINES)		
Stalk Position	Potentiometer	Wing Ctr
Blade Position	Potentiometer	Wing Ctr
Winglet Position	Potentiometer	Wing Ctr
Engine Speed (RPM)	Tachometer	Lower Cab
Operating Time	Hobbs Meter	Engine
Fuel Consumption	Measure	Fuel Cell
Manifold Pressure	MP Gage/Pots	Engine
Cylinder Head Temp	Thermistor	Engine
Oil Pressure	Press Transducer	Engine
Oil Temp	Resist Elem	Engine
Fuel Pressure	Transducer	Lower Cab
Fuel Injector	Pressure Transd	Engine
Fire Warning	Flame Det (opt)	Engine
Throttle Pos (actual)	Potentiometer	Engine
CONTROL SYSTEM		
Step Input Wing Vert	Potentiometer	Lower Cab
Step Input Wing Horz	Potentiometer	Lower Cab
Step Input Blade Yaw	Potentiometer	Lower Cab
Step Input Blade Pitch	Potentiometer	Lower Cab
Step Input Blade Coll	Potentiometer	Lower Cab
Shaft Encoder	Dig Resolver	Upper Cab

Test T5 - X.2 Remote Operation

Recognizing, from the mission/user interactions, that a very desireable mode of operation is an unmanned X.2 aircraft, AeroLift has configured the vehicle so that remote operation may be assessed. The fuel cell and the APU in the lower cab can be removed from the cab and located on the lower point of the cable truss. The lower cab can then be removed. The resultant configuration can then be remotely operated through the radio link from the detached lower cab.

In this mode, a series of tests will be performed to illuminate the merits or problems of the existing X.2 with respect to remote operations.

Details of required tests will be developed on Checklists/Test Cards prior to test initiation.

Results of Test T5 will be evaluated in the Quick Look Report. Video coverage will be provided during test execution.

5.5 Data Acquisition and Analysis

At noted in **Figure 25**, the current X.2 aircraft has many sensors installed which were used to gather data in the previous flight test program.

For the planned system tests there are a mix of requirements for data acquisition, from very few to a significant number of measurements. To accommodate this range the acquired AACOM telemetry subsystem (described earlier in Section 4.0, Description of Flight Test Articles) has the capability to handle 64 channels of analog sources and 96 channels of digital data.

Test T1 - 36 Foot Model Ground Handling and Test T2 - X.2 Ground Handling, have a nonpowered aircraft and will require minimal data needs; e.g., measurements to determine static lift. Portions of Test T3 - X.2 Tether Variations, will have powered aircraft phases which require considerably more instrumentation; e.g., monitor power, record control inputs and outputs, and monitor items related to safety. Test T4 - X.2 Data Acquisition and Test T5 - X.2 Remote Operation will require the most instrumentation -- likely, on the order of the Master Measurement List as shown on **Figure 25**.

AeroLift will perform end-to-end calibrations of all required instrumentation for each system test phase, demonstrating that sensors function properly and that data acquisition and display are suitable; e.g., scale factors. Tabulated and/or

graphical calibration data will be provided to DARPA/Aerospace, as well as description of calibration methods and instruments used.

5.6 Quick Look Reports

The Quick Look Reports are important feedback documentation for AeroLift and DARPA personnel. They provide near real time information, necessary between test series, to allow for judgments on the subsequent tests or need for repetition of portions or all of just completed tests.

AeroLift shall develop these reports in a standard format (refer to **Figure 26**, following this page) which will allow for coverage of:

- Test anomalies related to hardware, flight crews, ground crews, and associated GSE
- Occurrences/problems pertinent to safety issues
- Ranking of success levels achieved in obtaining required performance data
- Critiques from individual test team members viewpoints, and
- As a result of overall assessment, recommendations for subsequent test activities.

These reports shall be prepared by AeroLift immediately following the conclusion of each individual test, with a copy transmitted to DARPA within 24 hours of the completed test. In addition, the Quick Look Reports, along with data acquired from the completed test; e.g., manual recording and automatic recording, shall be made available in the same time frame to Aerospace for related program activities.

5.7 Final Report

The Final Report shall be a summary of all system test activities performed under the contract, starting with the basic test objectives and proceeding through the FRR, the individual tests, any data analysis performed, and subsequent conclusions and recommendations by AeroLift with respect to the system test program results. Material previously generated in this detailed Limited Flight Test Plan, during the FRR or through Quick Look Reports will be used as appropriate in the development of the Final Report. The basic outline to be used for the Final Report shall be as follows:

Figure 26. QUICK LOOK REPORT.

AEROLIFT, INC.
4105 Blimp Blvd
Tillamook, OR. 97141

Quick Look Report X.2 CycloCrane N240AL

DATE			ROLL-OUT		Barometric Pressure	
day	month	year	hour	minute	Outside Air Temperature	
					Hangar Temperature	
TEST NUMBER			ROLL-IN		Winds	
			hour	minute		
					Clouds	
LOCATION			FLIGHT TIME			
			hours	minutes	Forecast	

DISCREPANCIES NOTED DURING FLIGHT

TEST OBJECTIVES

COMMENTS

Submitted by:________________
J. J. Morris
Vice President Operations
Test Pilot

- Introduction
- Basic Objectives
- Description of X.2 CycloCrane, the 36 foot model and GSE
- Organizational Structure (Air and Ground Crews)
- Preparation Activities
- Flight Readiness Review
- Test T1 - 36 Foot Model Ground Handling
- Test T2 - X.2 Ground Handling
- Test T3 - X.2 Tether Variations
- Test T4 - X.2 Data Acquisition
- Test T5 - X.2 Remote Operations
- Overall Observations on Test Results
- Conclusions and Recommendations.

All relevant, detailed data/documentation developed during the FRR and flight tests shall be provided to the DARPA/Aerospace as it is developed and will not be included in the Final Report, other than in distilled or encapsulated versions, as appropriate.

The Final Report shall be delivered to DARPA/Aerospace within 15 days of completion of the final test of the contract.

APPENDIX A

EXAMPLE OF X.2 GROUND HANDLING PROCEDURES

CYCLOCRANE ROLLOUT AND GROUND HANDLING PROCEDURES

GHE EQUIPMENT NEEDED

a. Mobile Mooring Mast
b. Mast Tow Vehicle
c. Port and Starboard Stalk
d. Port and Starboard Tail Winch Trucks
e. Tail Ballast Tank
f. APU
g. APU Power Cord
h. Lower Cab Transporter

STAND-BY EQUIPMENT

a. Fuel Truck
b. Bucket High Ranger
c. Boom Truck
d. MRS

NOTE: Parking brakes applied on GHE when parked during procedures.

GHE engines are to be kept running.

GHP GROUND HANDLING PERSONNEL STATION ASSIGNMENTS

Kevin Whitworth	-	Top of Mast
John McLain	-	Mast Tow Vehicle
Jennifer Sauter	-	Starboard Stalk
Butch Gallucci	-	Port Stalk
Pete Perez	-	Lower Cab Transporter
Floyd Case	-	Port Tail Winch Truck
Mark Govers	-	Port Tail Winch Truck
Eric Baker	-	Starboard Tail Winch Truck
Loran Roberts	-	Starboard Tail Winch Truck
Joe Dick	-	Safety Officer
Steve Shelfer	-	Tail Ballast

LINE DESCRIPTIONS

L1 — **NOSE LINE**

1/2" Dia
[illegible]' Len

This line is attached to the nose docking cone. It is used for undocking and docking of ship to the mast winch docking system.

L2 — **PORT BOW LINE**

1/2" Dia
280' Len

This line is used on bow winch trucks for taking lift loads for undocking and raising/lowering of ship operations.

L3 — **STARBOARD BOW LINE**

1/2" Dia
280' Len

This line is used as a safety on bow winch truck during undocking, docking, raising, and lowering ship operations.

L5 — **LOWER CAB RETRIEVAL LINE**

9/16" Dia
150' Len

This line is used on the release and retrieval operations of ground handling.

L6 — **STALK DROP LINES**

1/2" Dia
99' Len

There are four (4) lines. Each is prepacked on the end of each stalk.

L7 — **TAIL BALLAST LINE**

1/2" Dia
50' Len

This line is used on GHE during hangar rollout and flight operations. During raising and lowering it is used as a safety.

L8 — **PORT TAIL LINE**

1/2" Dia
275' Len

This line is used on GHE during hangar rollout and flight. During raising and lowering it is used as a safety.

L9 — **STARBOARD TAIL LINE**

1/2" Dia
275' Len

This line is used on GHV during hangar rollout and flight operations. During raising and lowering of ship it is the main winch line.

ROLLOUT PROCEDURES

1		Preflights will have to be done before briefing. After briefing GHP will then take assigned stations. When everyone is in position, radio communication checks by GOD will occur. After communication check, rollout will start with the mast tow vehicle starting, followed by GHV. Radio communications while rolling through hangar doors ("A" zone) will be kept to a minimum.
2	Don	Transfer hangar power to APU.

FLIGHT PAD GROUND HANDLING OPERATIONS

3		When flight pad designation is reached DGH will instruct on positioning of GHE (depending on wind direction with nose into wind). Wind speed and atmospheric conditions will be recorded.
4	Joe	Record time, wind speed and atmospheric conditions.
5		Raising of ship begins.

RAISING SHIP ON MAST PROCEDURES

6	John	APU started and adjust Variac.
7	John Ken/Don	Mast raising checklist completed. Report. Begin stalk checklist.
	Steve	To tail ballast. Releases Kevlar onto tail ballast patform.
8	Pete/John	Lower cab transport vehicle will be positioned forward of rotor plane. Uncoil forward Kevlar cables (clear of stalk, wind, etc.).
9	Mark/Loran	Port and starboard tail GHV will be positioned forward of tail during rigging.
10	Butch	Port stalk GHE will be released. Report stalk checklist complete.
11	Jennifer	As ship goes up, starboard stalk will be released when port stalks 3' above stalk GHE. Report stalk checklist complete.
12	John	Announces mast raising.
13	Steve	Tail ballast will be kept tight and let up during raising.
14	Floyd/Eric	Keep level position of ship.
15	John	Announces mast up.

SHIP UNDOCKING PROCEDURES

16	Steve	Takes lift load with tail ballast.
17	Mark/Floyd	The tail port GHE will relocate and position itself on centerline of ship, forward of tail (10' - 20').
18	Pete/Art	Move lower cab to behind rotor plane position.
19	JJ/Don or JJ/Art	Position stalks for forward flight.
20	Loran	Take L8 to front of port GHE and attaches as safety line. Tail starboard GHE (Chevy) proceed to front of ship. Forward GHE will position at mast on centerline of ship (15' behind mast).
21	Steve	Release tail ballast. L7 is to be unattached. Handle L8 as safety.
22	Loran/Eric	L2 to winch (Loran) and L3 safety (Eric).
23	Loran/Eric Mark/Floyd	Both rucks will then rig for undocking. Rig for flight capability with the rigging of L2 and L3 on forward GHE. L8 and L9 on aft GHE.
24	Eric	Forward GHE winches to take lift load with instructions from top mast person (Kevin) on amount of force needed applied for undocking.
25	Jennifer/Don	Aft sling cables attacked.
26	Steve	GOD will then contact Flight Crew for clearance to undock.
27	Kevin	Unplug APU on mast; release clearance and report.
28	Don	Starts truck APU. Report voltage.
29	Kevin	Following clearance approval, announce undocking. L1 will be passed down for storage as flight article.

SHIP UNDOCKING PROCEDURES (CON'T)

30	Art	Gets into cab.
		Crew starts control check. Top lower cab rigger will position rigging for flight article.
31	Eric/Floyd	Forward and aft GHE let up ship. Rigging and raising of ship will then proceed.
32	Steve	L5 rigged. Resume lift load responsibility. Then goes on top of cab for sling rigging.
33	Eric/Loran	L1, L2 and L3 will be positioned for flight on lower cab.
34	John	Backs mast away from ship. Remain in truck.
35	Floyd/Butch	L8 and L9 will be released for flight.
36	JJ/Art	Start engines. Checklist begins.
37	Steve	On start of engines, truck APU stops. APU plug pulled. GHP will position for retrieval of ship.
38	JJ/Art	Begin rotation.

SHIP FLIGHT RETRIEVAL PROCEDURES

DGH WILL ANNOUNCE LANDING
GHE AND GHP WILL POSITION THEMSELVES

RETRIEVAL GHP POSITION ASSIGNMENTS

Steve/Pete	Lower Cab	Support vehicle/beneath lower cab
Loran/Eric	Forward GHE	
Floyd/Mark	Aft GHE	

RETRIEVAL PROCEDURES

39	Art/JJ/Steve	GOD instructs from what order L1, L2 and L3 will be released by Flight Crew.
40	Art/JJ	Turns stalks to forward flight.
41	Kevin/Eric Loran	Unhook L1 and take to upper mast winch for docking. Top of mast L1 line will be rigged for winching in and docking. Forward GHE will attach lines.
42	Floyd/Mark	L8 and L9 will be attached to aft GHE.
		The aft GHE will proceed forward of tail while winching. Forward GHE will hold position. Forward and aft GHE will then winch down ship until L5 line is positioned for winching.
43	Steve	Winch down lower cab to locked position. Forward and aft GHE will follow with lowering operation. Once lowered, cab is locked in transport truck.
44	Don	Truck APU will, be plugged in and started on Flight Engineer's instruction.
45	Floyd/Mark Eric/Loran	Forward and aft GHE will rig for docking. When proper mooring direction is found forward and aft GHE will lower ship for docking to mast with nose high attitude kept.

SHIP FLIGHT RETRIEVAL PROCEDURES (CON'T)

46	John	Mast will be brought up wind for docking.
47	Steve	Aft sling cables unattached and returned behind tail GHE.
48	Pete	While lowering of ship, lower cab transport truck moves forward out of rotor plane.
49	Steve/Kevin Floyd/Mark/ Eric	Ship lowering begins and nose winched in for docking.
50	Kevin	Announces when ship safely docked. Reports APU hookup.
51	Art/JJ	Lower stalks positioned to hover.
52	Don	Turns off truck APU.
53	John	Starts mast APU. Adjust Variac.
54	Art/JJ/Butch	L6 lines released, if necessary.
55	Jennifer/ Butch	Handle L6 lines.
56	Pete	Lower cab truck moves forward.
57	Don/Jennifer	Sling cables coiled and stored for roll-in.

LOWERING SHIP ON MAST PROCEDURES

58	Eric/Loran	Once ship is docked, the forward GHE proceed to tail behind aft GHE winch truck.
59	Art/JJ	Rotate stalks to hover.
60	Jennifer/Don Butch	Place stalk GHE in place. Take hold of L6's mast is being lowered, if necessary. L6 attached to stalk GHE. This keeps ship in "X" configuration.
61	Steve	Tail ballast take lift load.
62	Floyd/Mark	Tail port GHE positions for lowering of ship and roll-in.
63	Loran/Eric	Tail starboard GHE position; for lowering ship and roll-in.
64	John	Announce lowering of mast with acknowledgment from tail GHP. Announce mast down.
65	Butch/Jennifer Don	Stalks secured to GHE; engine stalk first. Open by-pass.
66	Jennifer	Non-engine stalk secured to GHE. Open by-pass.
67	Steve/Don/Ken	Secure forward transport cables. Once flight article lines are stored GOD will instruct mast vehicle to start roll-in.

ROLL-IN PROCEDURES

Roll-in will start with mast moving first. The other GHE following. Roll-in speed determine by DGH. Radio communications while rolling through hangar doors ("A" zone) will be kept to a minimum. Roll-in stops when mast reaches hangar mooring position.

68	Art/JJ/Kevin	Wings checked in hover position when entering "A" zone.

APPENDIX B

EXAMPLES OF PRE AND POST FLIGHT PROCEDURES

ELECTRONICS SYSTEM PREFLIGHT

CONDITIONS: Ballonet checked out and flight ready; mechanical personnel out. Computer on in lower cab.

MATERIALS: Intercoms (2), Small-bladed screwdriver, Pencil, Checklist, DMM, Duct tape, Vaccum cleaner.

MEN: Two (1 upper cab, 1 lower cab)

AEROLIFT, INC. CYCLO-CRANE N240AL

TECH	ITEM	Inspector DATE / /
	1.	Ascend mast - open disconnect on platform batteries
	2.	Plug in intercom and contact lower cab
	3.	Check pressure control rack
		A. (4) DP cell plugs secure
		B. Power plugs secure
		C. Switch relay Plug secure
		D. Status plug secure
		E. DP zero plug secure
		F. Dummy plug in helium vent "A" secured
		G. Helium vent "B" plugged in and secured
	4.	Upper cab reports when helium vents are connected
	5.	Stand by for zero checks. Lower cab notes any descrepancies.
	6.	Lower cab notes ballonet position and pressures on main and back-up.
	7.	Lower cab disables all pressure control functions and instructs upper
		cab to connect telemtetry pressure control input.
	8.	Lower cab scans telemetric pressure control readings for validity.
	9.	Lower cab re-checks zeroes.
	10.	Lower cab enables fans and allows system to pressurize.
	11.	Lower cab turns off ground support power.
	12.	Upper cab takes voltage readings on both buses -- report readings.
	13.	Repeat readings with fan running -- report readings.
	14.	Restore ground support power.
	15.	Check switch panel:
		A. Main power CLOSED
		B. Panel power CLOSED
		C. Stalk 2 CLOSED
		D. Stalk 4 CLOSED
		E. Brake release OPEN

ELECTRONICS SYSTEM PREFLIGHT

CONDITIONS: Ballonet checked out and flight ready; mechanical personnel out. Computer on in lower cab.

MATERIALS: Intercoms (2), Small-bladed screwdriver, Pencil, Checklist, DMM, Duct tape, Vaccum cleaner.

MEN: Two (1 upper cab, 1 lower cab)

AEROLIFT, INC. CYCLO-CRANE N240AL

TECH	ITEM	Inspector DATE / /
		F. Gage power ON
		G. All switches in power supply rack ON
	16.	Lower cab brings up computer
	17.	Upper cab connects rate gyro
	18.	Lower cab turns gyro ON
	19.	Upper cab moves intrument platform; response is noted on CRT
	20.	All gyros OFF
	21.	Lower cab brings pressure system to FLIGHT READY
	22.	Upper cab resumes inspection
	23.	Check remaining plugs and circuit boards for security
	24.	Read rotation counter; report
	25.	Duct tape as requirea
	26.	Vacuum upper cab
	27.	Remove intercom, vacuum, tools, lights
	28.	Plug in rate gyro
	29.	Remove pressure control line from nose
	30.	Remove AC line from nose
	31.	Close disconnect on platform

AIRFRAME DAILY WORK FORM

AEROLIFT, INC.

CYCLO-CRANE N240AL

INSPECTOR:	DATE / /	TIME am pm
CREW CHIEF:	DATE / /	TIME am pm
TECH:	DATE / /	TIME am pm

JOB DESCRIPTION

MATERIALS USED

WEIGHT AND LOCATION

REMARKS

AIRFRAME PREFLIGHT CHECKLIST

AEROLIFT, INC. CYCLO-CRANE N24OAL

TECH		Inspector Time Date / /
	1	Nose Docking System - safety lock ON
	2	Forward Sling Bearing Assembly - check sling cable attachment points
	3	Ballonet Winch Inspection
		A. Brake - tension strap REMOVED
		B. Chains and tension lubrication
		C. Oil level in gear boxes
		D. Cable covers - fasteners tight and check cable lubrication
		E. Instrumentation - check mounting grackets and drive chains
		F. Wiring - plugs connected
	4	Ballonet Vent - check operation
	5	Nose Cap Assembly - roll assembly free to move, check seal
	6	Ballonet Retraction Fitting Assembly - exercise system for cable movement
	7	Structural Cables and Flex Couplings (See attached drawing)
		A. Station A
		B. Station B
		C. Station C
		D. Station D
		E. Station E
		F. Station F
		G. Station H
		H. Station I
		I. Station J
	8	Stalk Tubes and DP Cells - check mount and plugs
	9	Aft Cap Roll Assembly - check movement and seal
	10	Aft Spreaders and Cables - check tension and alignment
	11	Aft Sling Bearing Assembly - check sling cable attachment points
	12	Blade Support Cables - check and attach lines for security
	13	Airfoils - check integrity
	14	Airfoil Control Cables - check integrity
	15	Blade to Engine Bearing Assembly - general inspection
	16	Stalk Support to Blade Rotating Assembly - check bolt assembly and lubrication
	17	Cabane Tubes - check cable attachments, tube splice, fabric bellows
	18	Helium Fill Caps - check safety lock and for leaks
	19	Airflow Instruments - general inspection
	20	L6 Lines - packed, charges loaded, charge wire attached
	21	Tail - check bearing assembly, cables, ballast line pass-through

COMMENTS

AIRCRAFT FLIGHT READINESS RELEASE

AEROLIFT, INC. CYCLO-CRANE N24OAL

FLIGHT NO.	DATE			TIME		DAY OF WEEK
	month	day	year	hour	minute	

ACCEPTABLE DISCREPANCIES	
1	
2	
3	
4	
5	
6	
7	
8	
9	

	Gallons	Pounds		Nose	Tail	TOTAL	C.G.
FUEL			LIFT				
BALLAST							

PILOT	
COPILOT	
FLIGHT ENGINEER	
CREW CHIEF	
SAFETY OFFICER	

	SIGNATURES	MONTH	DAY	YEAR	HOUR	MIN
PILOT						
CREW CHIEF						

NOTICE: This aircraft is not released until signed off by pilot.

COMMENTS

GROUND HANDLING EQUIPMENT

AEROLIFT, INC. CYCLO-CRANE N24OAL

Tech	Inspector	month	day	year	hour	minute

	CAB TRANSPORTER	FORD PU	CHEVY PU	MAST TOW TRUCK	FUEL TRUCK	BOOM TRUCK
Fuel						
Oil						
Coolant						
Belts						
Battieries						
Tires						
Windows clean						
Run-up check						
Winch batteries						
Winch condition						
APU fueled & checked						
Latch lubed with pins						
Fuel can full and aboard						

	SUPPORT DOLLIES		TAIL BALLAST	MAST
	port	starboard		
Tires				
Hammer				
Fire extinguisher				
Clean - No debris				
Batteries				
Appropriate weight				
APU gas				
APU belt				
Top Winch				
Emerg lowering wrench				
Hitches each end				
Mast extension winch				

FLIGHT DISCREPENCIES REPORT

AEROLIFT, INC.　　　CYCLO-CRANE N24OAL

TIME			FLIGHT NUMBER	month	day	year	Ground Handling Manager
hr	min	sec					
			Released from mast	Pilot			
			Released from GHV				
			First engine start	Co-pilot			
			Begin rotation				
			Second engine start	Flight Engineer			
			First engine shutdown				
			Second engine shutdown	Crew Chief			
			Total time				

DISCREPANCY	ACTION TAKEN	ACTION BY

SIGNATURES

PILOT

CREW CHIEF

AIRFRAME IMMEDIATE POST FLIGHT CHECKLIST

AEROLIFT, INC. CYCLO-CRANE N24CAL

TECH		Inspector Time Date / /
	1	Helium Vent CLOSED
	2	Measure Tail Lift
	3	Ballonet Retraction Fittings Assembly - check for excessive cable movement
	4	Ballonet Pressure Relief Valve - check function
	5	Ballonet Winch Inspection
		A. Chains and tension lubrication
		B. Cable covers - fasteners tight and check cable lubrication
		C. Instrumentation - check mounting grackets and drive chains
		D. Wiring - plugs connected
	6	Nose Cap Assembly - roll assembly free to move, check seal
	7	Ballonet Retraction Fitting Assembly - exercise system for cable movement
	8	Structural Cables and Flex Couplings (See attached drawing)
		A. Station A
		B. Station B
		C. Station C
		D. Station D
		E. Station E
		F. Station F
		G. Station H
		H. Station I
		I. Station J
	9	Blade and Stalk Support Cables - general inspection
	10	Airfoil Control Cables - check integrity
	11	Cabane Tubes - check cable attachments, tube splice, fabric bellows
	12	Helium Fill Caps - check safety lock and for leaks
	13	Airflow Instruments - general inspection

COMMENTS

ELECTRONICS POSTFLIGHT INSPECTION

AEROLIFT, INC. CYCLO-CRANE N24OAL

DATE			TIME STARTED		TIME FINISHED		FLIGHT NUMBER	Crew Chief
month	day	year						
								Technician

STALKS				VISUAL INSPECTION & SECURITY	
1	2	3	4		
				1	Wing box (inside and out)
				2	Cabling (to and from)
				3	Servo valve & feedback pot cannon plugs(3 each)
				4	Streamer system
				5	Cartridge removed
				6	Tie-down jettison system
				7	Cartridge removed
				8	Hydraulic filter press-to-fit

COMMENTS

MAINTENANCE/MODIFICATIONS INDEX

AEROLIFT, INC. CYCLO-CRANE N240AL

DATE ENTERED	AUTHORIZED	DATE START.		WORK DESCRIPTION	DATE COMPLETED	TECH	INSPECTOR

APPENDIX C

EXAMPLE OF PILOT TEST CARDS

FLIGHT DATA RECORD

CYCLO-CRANE N240AL TEST T3

FLIGHT CONDITIONS	CONFIGURATIONS
Hover	Buoyancy
NR Forward	Load
Both	Sling
Page 17 of 18	Fuel

Task #	TASK DESCRIPTION
513	FE inputs pitch SF and
514	P commands STOP at 15 deg. UP
515	P stabilizes aircraft
516	FE presets pitch 100% DOWN
517	FE inputs pitch SF and
518	P commands STOP at 15 degrees DOWN
519	Pstabilizes aircraft
520	FE takes all controls except WING VERTICAL
521	FE presets yaw 100% RIGHT ( )
522	FE inputs yaw SF and
523	P commands STOP at 20 degrees RIGHT
524	P stabilizes aircraft
525	FE presets yaw 100% LEFT ( )
526	FE inputs yaw SF and
527	P commands STOP at 20 degrees LEFT
528	P stabilizes aircraft
529	FE takes all controls except WING VERTICAL
530	FE presets wing horizontal 100% RIGHT ( )
531	FE inputs wing horizontal SF and
532	P commands STOP when RIGHT thrust established
533	P stabilizes aircraft
534	FE presets wing horizontal 100% LEFT ( )
535	FE inputs wing horizontal SF and
536	P commands STOP when LEFT thrust established
537	P stabilizes aircraft
538	FE takes all controls except WING VERTICAL
539	FE presets wing vertical 100% UP ( )
540	FE inputs wing vertical SF and
541	P commands STOP when UP thrust established
542	P stabilizes aircraft
[illegible]13	FE presets wing vertical 100% DOWN ( )
544	FE inputs wing vertical SF and

CYCLO-CRANE N240AL TEST T3

FLIGHT CONDITIONS	CONFIGURATIONS
Hover	Buoyancy
NR Forward	Load
Both	Sling
Page 18 of 18	Fuel

Task #	TASK DESCRIPTION
545	P commands STOP when DOWN thrust established
546	P stabilizes aircraft
547	FE takes all controls except WING VERTICAL
548	FE presets FORWARD thrust 100% ( )
549	FE inputs FORWARD thrust SF and
550	P commands STOP when FORWARD thrust established
551	P stabilizes aircraft
552	FE presets AFT thrust 100% ( )
553	FE inputs AFT thrust SF and
554	P commands STOP when AFT thrust established
555	P stabilizes aircraft
556	FE brings #4 engine to FULL power
557	FE proceed with SECOND ENGINE START CHECKLIST
558	P makes normal approach to cab transport vehicle
559	P maintains hover
560	GC secures L5
561	When L5 secured, FE shuts down engines (normal)
562	GC recovers and secures aircraft
563	GC performs roll-in
564	
565	
566	
567	
568	
569	
570	
571	
572	
573	
574	
575	
576	

APPENDIX D

EXAMPLE OF WEIGHT AND BALANCE DATA

WEIGHT AND BALANCE
(STATIC LIFT)

AEROLIFT, INC. CYCLO-CRANE N240AL

INSPECTOR: TIME DATE / /

METEOROLOGICAL DATA

________ Barometric Pressure

________ Outside Air Temperature

________ Hangar Temperature

________ Humidity

AEROSTAT DATA

________ Ballonet Position

________ Ballonet/Hull Diff Pressure

________ Hull Pressure

AEROSTAT LIFT DATA

________ Lift at Nose (Calculated)

________ Lift at Tail

________ TOTAL AVAILABLE LIFT (Less Lower Cab)

LOWER CAB WEIGHT DATA

________ Cab Weight Empty

________ Fuel Weight

________ Crew Weight

________ Ballast Weight

________ TOTAL LOWER CAB WT.

STATIC LIFT SUMMARY

________ Total Lift Available

________ Total Lower Cab Weight

________ NET AEROSTATIC LIFT

________ Payload Weight

________ NET BUOYANCY

REMARKS